

TRELAWNEY TOBACCO RESEARCH STATION

Annual Report
for 1945



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Report of the Tobacco Research Board of Southern Rhodesia for the Year ended 31st December, 1945

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I—General

With an increased technical staff, there was a considerable expansion in the programme of experimental work.

Mr. I. P. Norval, the Plant Pathologist, returned from military service at the beginning of November, and resumed his work on fungal and bacterial diseases, both in the field and in the barns.

Mr. B. L. Mitchell, Entomologist from the Department of Agriculture, was resident on the Station from December, investigating soil insect pests of tobacco, with special reference to white grubs.

The series of experiments, extending over three years, designed by Mr. Jack to test cultural methods for control of eel-worm, was concluded. Mr. Jack left the Station at the end of June on his retirement.

On the manurial and varietal side of the work, the series of experiments commenced in the 1943-44 season were continued, and an experiment testing combinations of spacing, topping and varieties commenced. A further series of rotations were also commenced on third-year soil.

The season was, on the whole, favourable for tobacco, heavy yields of good quality leaf being obtained from the majority of the experiments. The total area under tobacco was 45 acres, of which 10 acres were planted for seed bulking. Details of tobacco sold are given in Table 1.

Weather Conditions

The rainfall was unusually light, the total for the season being the lowest recorded since the Station started. Planting conditions were difficult, but on the whole good stands were obtained. Once the crop was established, growing conditions were good and growth vigorous. On the older and reverted lands, particularly, growth was very vigorous, the leaf tending to run to a medium rather than a bright type. Detailed figures of the rainfall are given in Table 2.

Insect Pests

Crickets and wireworms were not so numerous as in the past few years, causing little damage. White grubs were, however, very prevalent and considerable loss of stand resulted in some experiments, more particularly in those planted in the mid-season.

Disease

Throughout the season, the tobacco was singularly free from leaf spotting diseases in the field. On some of the more heavily grown tobacco angular spot and alternaria appeared towards the end of the season, but did little damage. White mould was more prevalent than has been the case for many years. This disease appeared on the heavier type of plants, causing some damage in the first reapings. A

certain amount of barn rot occurred, but appeared to be controlled by the methods described in Section V of this Report. Apart from one variety trial, the incidence of mosaic was again low.

Presentation of Results

The results of the experiments were evaluated and tabulated in the same manner as last season. Standard prices, based on samples from each experiment, were again used to arrive at the price per pound. The prices are, therefore, comparable with those given in the 1943-44 Report. The results are again tabulated in two ways—one column giving the actual yield, price or value, while a second column expresses the results as a percentage of the average of the whole experiment under each heading.

A number of growers were confused when reading the 1943-44 Report by symbols used to test the significance or accuracy of the experiments. It may be mentioned here that “Z,” “F” and “t” are statistics which show whether or not the results of the experiment are significant. The Standard Error (S.E.) shows the accuracy of the experiment, while significant differences at the 5 per cent. and 1 per cent. points mean that the odds against any particular result being due to chance are 20-1 and 100-1 respectively. These details are given so that other investigators can assess the accuracy of any particular type of experiment. From the point of view of the commercial grower, only significant differences are important, and the other symbols may be ignored.

It is important that it should be appreciated that many of the results recorded are merely those obtained over a one-year period, and some of the tentative conclusions arrived at may need to be considerably modified.

Acknowledgments

We are again indebted to the Imperial Tobacco Company and to Messrs. J. Reid Rowland & Company, whose representatives classified the samples of tobacco.

TABLE 1.—DETAILS OF TOBACCO SOLD: 1944-45 CROP

Bales	Weight in lbs.	Gross Value		Average Gross Price Realized per lb.		Weighing and Auction Fees		Commission		Levy		Railage		Total Charges		Net Value		Average Net Price Realized per lb.	
		£	s. d.	d.	£	s. d.	£	s. d.	£	s. d.	£	s. d.	£	s. d.	£	s. d.	£	s. d.	d.
Tobacco Auctions, Ltd.	35	6,118	409 3 6	16.05	1 15 0	10 4 7	2 7 6	5 0	14 12 1	394 11 5	15.48								
Tobacco Auctions, Ltd.	17	2,375	165 3 5	16.69	17 0	4 2 7	18 6	1 16 1	7 14 2	157 9 3	15.91								
Tobacco Producers' Floor, Ltd.	31	4,772	385 12 0	19.39	1 11 0	9 18 0	1 17 0	1 3 6	14 9 6	371 2 6	18.67								
Tobacco Producers' Floor, Ltd.	29	4,681	369 18 9	18.97	1 19 0	9 5 0	1 16 6	1 2 2	14 2 8	355 16 1	18.24								
Tobacco Auctions, Ltd.	23	3,738	326 12 8	20.97	1 3 0	8 3 4	1 9 0	19 6	11 14 10	314 17 10	20.22								
Tobacco Auctions, Ltd.	17	3,147	310 4 1	23.66	17 0	7 15 1	1 4 6	11 9	10 8 4	299 15 9	22.86								
Tobacco Auctions, Ltd.	17	3,363	348 18 9	24.90	17 0	8 14 6	1 7 10	14 11	11 14 3	337 4 6	24.07								
Tobacco Auctions, Ltd.	1	223	24 12 5	26.50	—	—	—	—	—	24 12 5*	—								
Tobacco Producers' Floor, Ltd.	17	3,600	415 9 4	27.70	17 0	10 7 9	1 8 3	13 9	13 6 9	402 2 7	26.81								
Tobacco Producers' Floor, Ltd.	17	3,223	285 13 1	21.27	17 0	7 3 0	1 5 0	13 9	9 18 9	275 14 4	20.53								
Tobacco Producers' Floor, Ltd.	17	1,968	181 19 8	22.19	1 11 0	4 11 0	15 6	12 9	7 10 3	174 9 5	21.28								
Tobacco Auctions, Ltd.	5	203	17 2 10	20.26	5 0	8 7	1 8	8 5	1 3 8	15 19 2	18.87								
226	37,411	3,240 10 6	20.79	12 9 0	80 13 5	14 11 3	9 1 7	1 16 15 3	3,123 15 3	20.00									

* Donated to Tobacco Fund.

TABLE 2.—RAINFALL FOR SEASON 1944-45

Date	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1 ..	—	—	—	0.47	—	—	—
2 ..	—	0.06	—	0.06	0.01	—	—
3 ..	—	—	—	—	—	0.03	—
4 ..	—	—	—	0.75	0.97	0.01	—
5 ..	—	—	—	1.99	0.09	0.42	—
6 ..	—	—	—	0.04	0.03	—	—
7 ..	—	0.84	—	0.08	—	0.67	—
8 ..	—	0.10	—	0.34	—	—	—
9 ..	—	0.01	—	0.22	—	0.30	—
10 ..	—	—	—	0.65	0.10	0.46	—
11 ..	—	0.51	—	0.27	—	0.23	—
12 ..	—	0.02	0.18	0.01	1.18	—	—
13 ..	—	0.07	1.13	—	0.05	0.02	—
14 ..	—	—	0.47	—	0.45	—	0.26
15 ..	—	—	0.35	—	0.63	0.05	0.06
16 ..	—	—	—	—	0.53	0.04	—
17 ..	—	—	—	—	3.02	—	—
18 ..	0.50	0.50	—	—	0.10	—	0.02
19 ..	—	—	—	—	0.36	0.17	—
20 ..	—	—	—	—	0.12	—	—
21 ..	—	—	—	0.56	0.48	0.14	—
22 ..	—	—	0.02	0.03	0.03	—	—
23 ..	—	0.96	0.25	0.29	—	—	—
24 ..	—	—	0.16	—	—	—	—
25 ..	—	0.37	0.11	0.27	0.10	—	—
26 ..	—	—	—	0.08	—	—	—
27 ..	—	—	0.34	0.01	—	0.14	—
28 ..	—	0.18	0.20	0.38	—	—	—
29 ..	—	0.05	—	0.03	—	—	—
30 ..	—	1.22	—	0.04	—	—	—
31 ..	—	—	—	0.02	—	—	—
Total	0.50	4.89	3.21	6.59	8.25	2.68	0.34

Seasonal Total, 26.46 inches

II—Agronomy

As in the previous season, the agronomic investigations were divided into a number of sections, as follows:—

- (a) Experiments to test methods of application of compost and fertilizer and to determine the best sources of nitrogen.
- (b) Spacing and topping trials.
- (c) Experiments to test the effects of different levels of the main fertilizer ingredients in varying combinations with each other, and with compost.

As it was desirable to obtain information as to the effect of spacing, topping and fertilizer ingredients in different varieties, a number of varieties were included in sections (b) and (c), the experiments being carried out in collaboration with Dr. Moffett. The results of these experiments are discussed in Part IV of this Report.

The trials discussed below are, therefore, only those included in section (a) above.

DESCRIPTION AND RESULTS OF EXPERIMENTS

1.—METHOD OF APPLICATION OF COMPOST

The object of the experiment, which was initiated in the 1943-44 season, was to ascertain if the yield and quality of the crop were affected by the manner in which compost at different levels was applied. Nine treatments were tested as follows; the initial planting in all cases was made in hills:—

- (1) $2\frac{1}{2}$ tons per acre in hills before planting;
- (2) 5 tons per acre in hills before planting;
- (3) $2\frac{1}{2}$ tons per acre broadcast before planting;
- (4) 5 tons per acre broadcast before planting;
- (5) $2\frac{1}{2}$ tons per acre round plants 3 weeks after planting;
- (6) 5 tons per acre round plants 3 weeks after planting;
- (7) $2\frac{1}{2}$ tons per acre ground compost, round plants 3 weeks after planting;
- (8) 5 tons per acre ground compost, round plants 3 weeks after planting;
- (9) No compost.

The soil was a light grey, coarse sand, opened in August, 1942, carrying its second successive crop of tobacco. Other experimental details were as follows:—

Planted 28th December, 1944.

Replanted 5th January, 1945.

Fertilizer was applied as follows:—

- (1) 150-lbs. per acre of Standard (8-6-8) on 24th December, 1944.
- (2) 150-lbs. per acre of Standard (8-6-8) on 25th January, 1945.

Treatments (5), (6), (7) and (8) were composted on 18th January, 1945.

The variety used was Bonanza.

A randomized block lay-out was used with six replications, each plot being $1/40$ th acre in extent.

The results are summarized in Table I, as follows:—

TABLE I

Treatment	Yield lbs.	% of Mean	Value	% of Mean	Price Pence	% of Mean
1	600	94.3	£19.03	92.3	7.65	98.2
2	639	100.5	£20.89	101.2	7.85	100.8
3	610	95.9	£19.44	94.2	7.66	98.3
4	657	103.3	£21.15	102.5	7.73	99.2
5	612	96.2	£19.86	96.3	7.79	100.0
6	628	98.7	£20.69	100.2	7.88	101.2
7	665	104.6	£22.27	107.9	8.08	103.7
8	707	111.2	£22.50	109.0	7.63	97.9
9	609	95.7	£19.90	96.4	7.85	100.7

Z Test not significant.

	Yield	Value	Price
Mean	636	£20.64	7.79
Standard Error ..	4.35%	4.49%	1.46%

No significant differences in yield, value or price.

Compost had no effect on yield, value or price per pound no matter how it was applied.

These results are in agreement with those obtained the previous season, although during the present season the experiment was located on a much poorer type of soil than in the previous year. The fact that growing conditions were ideal may in some measure have masked any possible effect of compost, but taken in conjunction with most previous experiments, the use of compost has not so far proved worthwhile.

2.—SOURCES OF NITROGEN

The object of the experiment, which was commenced in the 1943-44 season, was to ascertain the effect of nitrogen from different sources on the yield and quality of tobacco. The experiment is necessarily a long term project, as it is probable that climatic conditions may affect the results.

Nine treatments were tested, as follows:—

- (1) $\frac{1}{3}$ nitrogen from Nitrate of Soda, $\frac{2}{3}$ from Ammonium Sulphate;
- (2) $\frac{1}{3}$ Nitrogen from Nitrate of Soda, $\frac{1}{3}$ from Ammonium Sulphate and $\frac{1}{3}$ from Bloodmeal;
- (3) $\frac{1}{3}$ Nitrogen from Nitrate of Soda, $\frac{1}{3}$ from Ammonium Sulphate and $\frac{1}{3}$ from Ground Nut Cake;
- (4) $\frac{1}{4}$ from Nitrate of Soda, $\frac{1}{2}$ from Ammonium Sulphate and $\frac{1}{4}$ from Bloodmeal;
- (5) $\frac{1}{4}$ from Nitrate of Soda, $\frac{1}{2}$ from Ammonium Sulphate and $\frac{1}{4}$ from Ground Nut Cake;
- (6) $\frac{2}{3}$ from Ammonium Sulphate, $\frac{1}{3}$ from Bloodmeal;
- (7) $\frac{2}{3}$ from Ammonium Sulphate, $\frac{1}{3}$ from Ground Nut Cake;

- (8) $\frac{1}{3}$ from Ammonium Sulphate, $\frac{2}{3}$ from Bloodmeal;
 (9) $\frac{1}{3}$ from Ammonium Sulphate, $\frac{2}{3}$ from Ground Nut Cake.

The soil was a light grey sand, opened in November, 1943, and carrying its first crop of tobacco.

The source and total amount of phosphate and potash were kept constant, only the source of nitrogen being varied.

All plots received fertilizer at the following levels:—

P₂O₅ 72-lbs. N 24-lbs. K₂O 32-lbs.

Fertilizer was, therefore, applied at a rate equivalent to 400-lbs. per acre of 18-6-8 (Tobacco No. 4).

Other experimental details were as follows:—

Planted 28th December, 1945.

The variety used was Bonanza.

Fertilizer was applied as follows:—

(1) 200-lbs. per acre on 3rd January, 1945.

(2) 200-lbs. per acre on 29th January, 1945.

A randomized block lay-out was used with six replications, each plot being 1/40th acre.

The results are summarized in Table II, as follows:—

TABLE II

Treatment	Yield lbs.	% of Mean	Value	% of Mean	Price Pence	% of Mean
1	628	98.4	£21.48	99.7	8.20	101.3
2	637	99.8	£21.25	98.6	8.01	99.0
3	615	96.4	£21.05	97.7	8.19	101.2
4	686	107.5	£23.77	110.3	8.28	102.3
5	657	103.0	£21.35	99.2	7.81	96.6
6	642	100.6	£22.46	104.2	8.39	103.7
7	690	108.2	£23.58	109.4	8.20	101.3
8	590	92.5	£19.50	90.5	7.92	97.9
9	600	93.6	£19.47	90.4	7.77	96.4

Z Test not significant.

	Yield	Value	Price
Mean	638	£21.55	8.10
Standard Error ..	4.35%	4.76%	1.46%

No significant differences in yield, value or price.

None of the treatments had any effect on yield, value or price per pound, although it is noteworthy that the highest value, as in the previous season, was given in Treatment 4. The growing season was extremely dry, in consequence there was little loss by leaching, and it is probable that ample supplies of nitrogen were available from all the treatments.

Present indications are that the addition of organic nitrogen makes very little difference to yield or value, and should this prove to be the case over a number of years, it would result in a marked saving in the cost of fertilizer.

3.—METHOD OF APPLICATION OF FERTILIZER

The objects of the experiment, commenced in the 1943-44 season, were:—

- (a) To test two methods of incorporating the fertilizer in the soil;
- (b) To test the number of applications of fertilizer required;
- (c) To test the proportion of the total to be given with each application of fertilizer.

The experiment was of the split plot design, with four replications, each sub-plot being 1/40th acre.

The treatments were as follows:—

- (A) Fertilizer incorporated with soil round plants in hills.
- (B) Fertilizer placed in small holes adjacent to plants which were planted on ridges.

The following sub-treatments were then imposed on each of these main treatments:—

- (1) $\frac{1}{2}$ Fertilizer before planting, $\frac{1}{2}$ about 4 weeks after planting.
- (2) $\frac{2}{3}$ Fertilizer before planting, $\frac{1}{3}$ about 4 weeks after planting.
- (3) $\frac{1}{3}$ Fertilizer before planting, $\frac{2}{3}$ about 4 weeks after planting.
- (4) $\frac{1}{3}$ before planting, $\frac{1}{3}$ 3 weeks after planting and $\frac{1}{3}$ 5 weeks after planting.
- (5) $\frac{1}{2}$ before planting, $\frac{1}{4}$ 3 weeks after planting and $\frac{1}{4}$ 5 weeks after planting.
- (6) $\frac{1}{5}$ before planting, $\frac{2}{5}$ 3 weeks after planting and $\frac{2}{5}$ 5 weeks after planting.
- (7) $\frac{2}{5}$ before planting, $\frac{2}{5}$ 3 weeks after planting, and $\frac{1}{5}$ 5 weeks after planting.
- (8) $\frac{1}{4}$ before planting, $\frac{1}{2}$ 3 weeks after planting and $\frac{1}{4}$ 5 weeks after planting.

The soil was a grey sand, opened in October, 1943, carrying its first crop of tobacco. Other experimental details were as follows:—

Planted 24th December, 1944.

The variety used was Bonanza.

All treatments received 500-lbs. per acre of 8-6-8.

All plots received the first application of fertilizer on 20th December, before planting.

Treatments (4) to (8) were refertilized on 15th and 29th January, 1945.

Treatments (1) to (3) were refertilized on 22nd January, 1945.

Field Observations

In all cases where the fertilizer was thoroughly incorporated in the soil, growth was extremely rapid, and at maturity there was a striking difference in development in comparison with those plots in which the fertilizer was applied in holes. At no period was there any noticeable difference due to sub-plot treatments.

The results are summarized in Table III, as follows:—

TABLE III: MAIN PLOTS

Treatment			Yield lbs.	% of Mean	Value	% of Mean	Price Pence	% of Mean
A	..	..	797	106.1	£29.44	107.7	8.87	101.8
B	..	..	706	93.9	£25.22	92.3	8.55	98.2

Z Test significant.

Mean	..	Yield	751	Value	£27.33	Price	8.71
Significant							
Difference	..	—		£4.00		0.28d.	
Standard Error	..	2.88%		3.25%		0.71%	

A better than B in value and price.

TABLE III: SUB-PLOTS

Treatment			Yield lbs.	% of Mean	Value	% of Mean	Price Pence	% of Mean
1	..	..	802	106.8	£29.10	106.5	8.69	99.8
2	..	..	710	94.5	£25.47	93.2	8.61	98.9
3	..	..	725	96.6	£26.79	98.0	8.85	101.6
4	..	..	745	99.2	£27.74	101.5	8.93	102.5
5	..	..	741	98.6	£26.92	98.5	8.70	99.9
6	..	..	732	97.5	£26.30	96.3	8.60	98.7
7	..	..	812	108.1	£30.03	109.9	8.83	101.4
8	..	..	742	98.7	£26.25	96.2	8.47	97.2

Z Test not significant.

Mean	..	Yield	751	Value	£27.33	Price	8.71
Standard Error	..	5.48%		6.64%		1.72%	

Discussion

The results obtained are very different from those of the previous season, which emphasizes the important part played by climatic conditions. Where the fertilizer was properly distributed and incorporated in the soil, significantly better results were obtained than when it was concentrated in one comparatively small area. This result was largely to be expected, as the fertilizer is thus brought into contact with a larger number of feeding roots, leading to more rapid absorption of nutrients and thus quicker growth. In the previous season this effect was overshadowed by that due to rainfall intensity and distribution.

The sub-plot treatments have shown no effect this season, which was a particularly dry one with very little leaching. In consequence, it is probable that no matter how the fertilizer was applied, there was always sufficient available nitrogen present to ensure steady, even growth.

Although three applications of fertilizer have this year shown no advantage over two applications, it is probable that the former is more satisfactory to adopt, as it gives better results in a wet season, and just as satisfactory results in a drier year. The proportion of the total to be given with each application of fertilizer remains a moot point.

4.—COMMERCIAL FERTILIZER TEST

This was a continuation of the experiment reported last year, in which a fertilizer with a higher ratio of nitrogen to the other ingredients was compared with the Standard pre-war fertilizer—Tobacco No. 4 (Bloodmeal).

Four treatments were tested, as follows:—

- (1) 300-lbs. per acre of 18-6-8 (Tobacco No. 4, Bloodmeal).
- (2) 200-lbs. per acre of 14-8-10 (new type mixture).
- (3) 400-lbs. per acre of 18-6-8.
- (4) 300-lbs. per acre of 14-8-10.

The soil was a grey sand, opened in October, 1943, and carrying its first crop of tobacco.

Other experimental details were as follows:—

Planted 24th December, 1944.

Refilled 5th January, 1945.

The variety used was Bonanza.

Fertilizer was applied as follows:—

- (1) $\frac{1}{2}$ of fertilizer applied before planting.
- (2) $\frac{1}{2}$ of fertilizer applied on 25th January, 1945.

The results are summarized in Table IV, as follows:—

TABLE IV

Treatment	Yield lbs.	% of Mean	Value	% of Mean	Price Pence	% of Mean
1	729	99.3	£24.07	97.4	7.92	98.6
2	704	95.9	£23.47	94.9	7.84	97.6
3	692	94.3	£22.72	91.9	7.86	97.9
4	810	110.5	£28.63	115.8	8.49	105.9

Z Test not significant

	Yield	Value	Price
Mean	734	£24.72	8.03
Standard Error ..	7.91%	8.91%	3.06%

In both tests carried out with the new fertilizer there have been no significant differences, so that it would seem that the new fertilizer is as satisfactory as the old Tobacco No. 4.

III—Breeding and Selection

The breeding work was continued on lines similar to those outlined in the Report for 1943-44. The three main trials were again put down with seed from single plant selections. These trials were:—

- A.—A test of seven varieties including those most commonly grown commercially. The main object of this experiment is to provide the material for small bulk selections from which seed is propagated for distribution to growers.
- B.—A continuation of the variety trial including a number of recent introductions.
- C.—A continuation of the selection and testing of a number of selections made in the progeny of intervarietal crosses and strains of certain varieties.

In all cases, single plant selections were made on the basis of the cured leaf as well as on field characteristics. Some twenty plants were selected within each variety or strain, each plant being reaped and cured separately. Those which showed good field characteristics but which produced poor quality leaf were eliminated when an examination of the cured leaf was made. A number of small seed bulks, consisting of six to eight selected plants, were made with a view to bulking seed next season for distribution to growers.

DESCRIPTION AND RESULTS OF EXPERIMENTS

A.—This consisted of a continuation of the test of the same seven varieties as last season. The same piece of soil was used, this being the second consecutive crop of tobacco after reversion from weed fallow.

The experimental details were as follows:—

Planted 1st December; refilled 19th December.

Fertilizer was applied as follows:—

Before planting: 100-lbs. per acre 18-6-8 mixture.

3rd January: 100-lbs. per acre 8-6-8 mixture.

The experimental design was a Latin Square giving seven replications of each variety.

Field Observations

After a slow start, due to dry weather following the initial planting, the varieties for the most part grew out well. Virginia Bright, White Stem Orinoco and Yellow Mammoth were particularly promising at the commencement. Bonanza made a poor start, the plants being tall but weedy, although they subsequently filled out. Similar observations were made on the Bonanza selections in experiment C in the same field. It would appear that either the weather conditions were unfavourable to this variety, or that Bonanza does not show to the best advantage on the older soils. The varieties grown and a summary of the results are given in Table I, as follows:—

TABLE I

Variety	YIELD		PRICE		CASH VALUE PER ACRE		
	lbs. per Acre	% of Mean	Pence per lb.	% of Mean	£	s. d.	% of Mean
Jamaica Wrapper	1,066	101.4	7.87	99.5	35	1 0	101.2
Willow Leaf	1,014	96.5	8.07	102.0	34	2 0	98.5
White Stem Orinoco	1,116	106.2	7.75	98.0	36	0 0	103.8
Yellow Mammoth	1,083	103.0	8.00	101.1	36	3 0	104.3
Virginia Bright	1,056	100.5	7.83	99.0	34	12 0	99.9
Bonanza	1,027	97.7	7.93	100.2	33	18 0	97.8
Gold Dollar	994	94.6	7.88	99.6	32	15 0	94.5

The Z Test was not significant for yield, price or value

	Yield	Price	Value
Mean of all varieties ..	1,051-lbs.	7.91d.	£34 13 0
Standard Error ..	4.10%	2.39%	4.54%

The fact that the Z test was not significant indicates that the differences between varieties is due to soil conditions, and not to inherent varietal characteristics. It can only be concluded, therefore, that the differences between these varieties was not sufficiently great to show up on the type of soil on which the test was made, and under the weather conditions prevailing.

B.—IMPORTED VARIETIES

This trial consisted of a test of the same twelve varieties as last season, i.e., ten varieties from Canada, a local commercial strain of Jamaica Wrapper and a Station strain of Bonanza for comparison.

The test was carried out on a new piece of soil consisting of a pink sandy loam, opened and ploughed during the dry season. The experimental details were as follows:—

Planted 1st December; refilled 15th December (final stand good).

Fertilizer was applied as follows:—

Before planting: 100-lbs. per acre 14-8-10 mixture.

3rd January: 100-lbs. per acre 14-8-10 mixture.

20th January: 75-lbs. per acre Nitrate of Soda.

The experimental design was a randomized block lay-out, with six replications.

Field Observations

All the varieties grew well until the middle of January, when there was some checking. After the application of nitrate, growth was again good, the first yield being heavy and the quality on the whole good. There was very little fungal disease or mosaic.

Certain of the varieties appeared particularly promising from a field point of view. Among these were Nos. 5 and 6, both of which grew extremely well. No. 9 Duquesne again showed considerable variation in type.

The varieties tested, and a summary of the results, are given in Table II, as follows:—

TABLE II

No.	Variety	YIELD		PRICE		VALUE		
		lbs. per Acre	% of Mean	Pence per lb.	% of Mean	£	s.	d.
1	Bonanza Can. 68	1,035	97.5	9.76	103.1	42	0	0
2	Bonanza Can. 47	1,105	104.1	9.54	100.7	43	17	0
3	Bonanza (Station)	1,062	100.1	9.93	104.9	43	18	0
4	White Mammoth Can. 61	1,091	102.8	9.43	99.6	42	18	0
5	Proctor's Special Can. 71	1,157	109.0	9.30	98.2	44	15	0
6	Gold Dollar Can. 82	1,151	108.5	9.77	103.2	46	16	0
7	Gold Dollar Can. 69	1,019	96.0	9.39	99.2	39	18	0
8	Yellow Mammoth Can. 58	1,108	104.4	9.31	98.3	42	18	0
9	Duquesne Can. 72	949	89.4	9.65	101.9	38	2	0
10	Jamaica Wrapper Local	1,110	104.6	9.30	98.2	43	0	0
11	Harrison's Special Can. 66	956	90.1	8.94	94.4	35	12	0
12	White Stem Orinoco Can.	985	92.8	9.40	99.3	38	10	0

Z test significant at both 5% and 1% points for yield, price and value.

	Yield	Price	Value
Mean	1,061-lbs.	9.47d.	£41 17 0
Standard Error	3.54%	1.51%	4.15%

Significant Differences 5% :

108-lbs. or 10.2% ; 0.40d. or 4.2% ; £4 18s. 0d. or 11.7%

Significant Differences 1% :

142-lbs. or 13.4% ; 0.54d. or 5.70% ; £6 12s. 0d. or 15.72%.

Significant Differences may be summarized as follows:—

Yield at 5% point—

5 and 6 better than 7, 9, 11, 12.

2, 8 and 10 better than 9, 11, 12.

4 better than 9 and 11.

3 better than 9.

Yield at 1% point—

5 and 6 better than 9, 11, 12.

2, 8 and 10 better than 9 and 11.

4 better than 9.

Price at 5% point—

3 better than 4, 5, 7, 8, 10, 11, 12.

1 and 6 better than 5, 8, 10 and 11.

2, 4, 7, 9, 12 better than 11.

Price at 1% point—

3 better than 5, 7, 10 and 11.

1, 2, 6 and 9 better than 11.

Value at 5% point—

6 better than 7, 9, 11 and 12.

2, 3 and 5 better than 9, 11 and 12.

Value at 1% point—

6 better than 7, 9, 11 and 12.

5 better than 9 and 11.

Very marked differences again occurred within this group of varieties, certain of the results being consistent with those obtained from this experiment last season.

Numbers 1, 7, 9, 11 and 12 again gave yields considerably below the average for all varieties, while the varieties which proved to be most vigorous last season, i.e., 3, 4, 5, 8 and 10, for the most part gave yields above the average for the whole experiment. Numbers 2 and 6, which did not give very high returns last season, both showed yields well above the average for the season 1944-45.

On the basis of price, there is again considerable consistency with the results of the 1943-44 season. Numbers 1, 3, 6 and 9, which gave the best prices again, gave the highest returns, while in the lower price groups, Nos. 4, 7, 8, 10, 11 and 12 were again below the average for the whole experiment.

When the results are examined on the basis of value, it will be noticed that varieties having a low yield may give a good cash return, owing to the compensating effect of a high price per pound, while the cash value of some varieties with high yields is reduced by their low prices. The fact that these differences occur indicates that these varieties should be tested over a wider range of soil types than is at present possible.

C.—This experiment consisted of a test of further single plant selections from intervarietal crosses and strains of varieties. The same piece of soil as last year was used again. This was, therefore, the second consecutive crop of tobacco on soil which had previously carried two years' tobacco, fallow, maize, three years' Rhodes grass, tobacco.

The experimental details were as follows:—

Planted 1st December; refilled 15th December, Stand good.

Fertilizer was applied as follows:—

Before planting: 100-lbs. per acre 18-6-8.

3rd January: 100-lbs. per acre 8-6-8.

The same experimental design as last season was used, i.e., a Symmetrical Incomplete Block arrangement with six replications.

Field Observations

Growth was good on the whole, although the tobacco tended to be rather on the dark, heavy side. The varietal hybrids, for the most part, showed considerable uniformity of type within each selection. Selection No. 1 from Gold Dollar X Jamaica Wrapper was outstandingly vigorous in growth and uniform in type. The rains during the early part of the season were irregular, a fact which seemed to have an adverse effect on the Bonanza selections. In their early stages, these made poor growth, producing a lanky type of plant, but some of them filled out subsequently to give good yields.

White mould was more prevalent than has been the case in any season since the Station started. It was noticed that the Jamaica Wrapper selections seemed to be particularly susceptible to this disease, Nos. C22 and C23 in particular being attacked.

Mosaic was more prevalent than in previous seasons. Three selections—Nos. C4, C8 and C21 had 13%, 8% and 14.5% infection respectively, while over all the other selections the infection was about 2%.

Sufficient plants of the selection intended for C9 were not available, so a Station strain of Bonanza was substituted to complete the experiment.

The strains and selections, together with a summary of the results, are given in Table III. The number in the first column refers to the number under which each selection was grown, while the number in the third column refers to that given in last year's Report, and shows the parentage of the selections grown.

TABLE III

No. 1944-45	Selection	No. of Parent 1943-44	Yield	% of Mean	Price Pence	% of Mean	Value £ s. d.	% of Mean
C 1	Gold Dollar X Jamaica Wrapper F4	C 1	1,121	114.9	7.27	96.2	33 18 0	110.2
C 2	Do.	C 2	1,012	103.7	6.97	92.2	29 14 0	96.6
C 3	Do.	C 3	1,042	106.8	7.72	102.1	33 14 0	109.6
C 4	Bonanza X Willow Leaf F4	C 4	976	100.0	7.36	97.3	29 16 0	96.9
C 5	Do.	C 5	965	98.9	6.99	92.5	28 2 0	91.4
C 6	Do.	C 6	927	95.0	7.36	97.3	30 0 0	97.6
C 7	Do.	C 6	871	89.2	7.30	96.6	26 14 0	86.8
C 8	Bonanza X Jamaica Wrapper F4	C 7	926	94.9	7.54	99.7	29 1 0	94.5
C 9	Bonanza Station Strain	—	1,063	108.9	7.45	98.5	32 15 0	106.5
C10	Bonanza X Jamaica Wrapper F4	C 8	997	102.1	7.65	101.2	32 1 0	104.2
C11	Do.	C 9	902	92.4	8.09	107.0	30 10 0	99.2
C12	Do.	C 9	1,030	105.5	7.80	103.2	32 8 0	105.4
C13	Willow Leaf X Jamaica Wrapper F4	C10	989	101.3	7.53	99.6	32 0 0	104.1
C14	Do.	C11	991	101.5	7.51	99.3	31 0 0	100.8
C15	Do.	C12	961	98.5	7.88	104.2	31 11 0	102.6
C16	Do.	C12	997	102.1	7.47	98.8	31 3 0	101.3
C17	Bonanza	C13	913	93.5	7.54	99.7	28 12 0	93.0
C18	Do.	C14	905	92.7	7.68	101.6	28 1 0	91.2
C19	Do.	C14	1,004	102.9	7.84	103.7	32 14 0	106.3
C20	Do.	C17	980	100.4	7.72	102.1	31 16 0	103.4
C21	Do.	C18	905	92.7	7.36	97.3	27 15 0	90.2
C22	Jamaica Wrapper	C20	1,005	103.0	7.65	101.2	31 19 0	103.9
C23	Do.	C21	933	95.6	8.22	108.7	31 19 0	103.9
C24	Do.	C22	1,065	109.1	7.77	102.8	34 8 0	111.9
C25	Gold Dollar	C23	915	93.7	7.56	100.0	28 17 0	93.8

Z test significant for yield at 10% point; for price at 1%, 5% and 10% points.

	Yield	Price	Value
Mean of all varieties ..	976-lbs.	7.56d.	£30 15 0
Standard Error	5.91%	2.77%	7.01%

Significant Differences—

At 10%: 134-lbs. or 13.7%; 0.49d. or 6.48%; not significant.

At 5% : Not significant ; 0.59d. or 7.80% ; not significant.

At 1% : Not significant ; 0.78d. or 10.3% ; not significant.

With constant selection the degree of variation within these selections is probably becoming less each year. A less stringent test for significant differences was, therefore, applied, and differences have been tested at the 10% point as well as at the 5% and 1% points.

Significant Differences may be summarized as follows :—

Yield at 10% point—

No. 1 better than 4, 5, 6, 7, 8, 9, 11, 15, 17, 18, 20, 21, 23 and 25.

Nos. 24 and 9 better than 6, 7, 8, 11, 17, 18, 21 and 25.

No. 3 better than 7, 11, 18 and 21.

No. 12 better than 7.

Price at 10% point—

No. 23 better than 1, 10, 13, 14, 16, 17, 18, 20, 21, 22 and 25.

No. 11 better than 1, 2, 4, 5, 6, 7, 8, 9, 13, 14, 16, 17, 21 and 25.

Nos. 12 and 19 better than 1, 2 and 5.

Nos. 3, 8, 10, 13, 14, 17, 18, 20, 22, 24 and 25 better than 2 and 5.

Price at 5% point—

No. 23 better than 1, 2, 4-9, 13, 14, 16, 17, 21 and 25.

No. 11 better than 12, 4-7, 9, 16 and 21.

Nos. 12 and 19 better than 2 and 5.

Price at 1% point—

No. 23 better than 1, 2, 4-7 and 21.

No. 11 better than 1, 2, 5 and 7.

Nos. 12 and 19 better than 2 and 5.

On the basis of yield, the results are not very consistent with those obtained last season, although some of those which gave yields well above the average last season have done so again this year.

On the basis of price, the results of the two seasons seem to be rather more consistent, and those whose parents gave the highest returns in the previous season have, for the most part, given returns above the average this season. The best returns in the 1943-44 seasons were given by families C 3, 9, 10, 12, 14, 17, 18 and 21. Eleven single plant selections were derived from these families, and out of these eleven, eight gave prices higher than average and included all the highest returns.

Among the lowest price returns in the 1943-44 season were families C 2, 4, 5, 7, 8, 11 and 20. Seven single plant selections derived from these families were grown last season. Of these seven selections, five gave returns below average, including the lowest prices in the whole experiment.

Taken on the value basis, in many cases yield and price compensate each other, and varieties with high yields and low prices may give as good results as those with lower yields and high prices. In this particular year, both soil conditions (second-year reverted land) and weather conditions combined to produce a medium rather than a bright crop, and under these conditions a vigorous variety would be at a disadvantage. The heavier yielding strains, such as C1, must, therefore, be tested on lighter soils, as they may be more suitable for conditions other than those under which they were grown.

Seed Distribution

Seed of the varieties Bonanza, Jamaica Wrapper, White Stem Orinoco, Willow Leaf and Gold Dollar was bulked for distribution to growers with the object of providing a nucleus from which they could select their own seed for some time with little chance of deterioration.

A small number of plants of each variety were selected both on the basis of field characteristics and on the quality of the cured leaf. From these a considerable acreage of each variety was grown, and a large number of selections made to provide a bulk of seed. The latter selections were made on the basis of field characteristics only, owing to the impossibility of examining the cured leaf of a sufficient number of plants. The seed distributed was, therefore, only one generation away from plants selected both in the field and on the quality of the leaf.

Seed was distributed at the rate of a maximum of 4 ounces per farm of each variety. As demand proved to be heavier than was anticipated, a total of 194 applications (covering 292 four-ounce units) being received, it was not possible to supply all growers who applied.

Details of applications received for each variety and quantity distributed are given in Table IV. The figures represent units of four ounces each of each variety :—

TABLE IV

Variety				Applications Received	Number Supplied	Number Not Supplied
Bonanza	....	....	....	118	103	15
Jamaica Wrapper	....	....	....	61	54	7
White Stem Orinoco	....	....	....	57	42	15
Willow Leaf	....	....	....	31	27	4
Gold Dollar	....	....	....	25	14	11
TOTAL				292	240	52

IV—Combined Varietal and Cultural Trials

The two experiments commenced in the 1943-44 season, combining fertilizer and variety tests, were continued, and a third experiment testing combinations of spacing and topping with different varieties was commenced.

The three experiments were as follows:—

- 1.—EXPERIMENT M. testing three varieties in combination with three levels each of phosphorus, potassium and nitrogen.
- 2.—EXPERIMENT S. combining three varieties with three levels each of compost and nitrogen.
- 3.—EXPERIMENT R. combining three varieties with four spacing distances and two heights of topping.

EXPERIMENT M.

The varieties and levels of fertilizer ingredients were kept the same as in the previous season, the treatments being:—

Varieties			P ₂ O ₅ per acre	K ₂ O per acre	Nitrogen per acre
V1	Jamaica Wrapper	....	P1 16-lbs.	K1 32-lbs.	N1 18-lbs.
V2	Bonanza	.... ....	P2 40-lbs.	K2 48-lbs.	N2 27-lbs.
V3	White Stem Orinoco	....	P3 64-lbs.	K3 64-lbs.	N3 36-lbs.

Nitrogen was supplied as $\frac{1}{3}$ Nitrate of Soda, $\frac{1}{3}$ Ammonium Sulphate and $\frac{1}{3}$ Bloodmeal.

P₂O₅ was supplied as 20% Super-phosphate, and K₂O as Muriate of Potash.

The experimental design was a split plot arrangement, similar to that of the previous season, but with three replications of the main plots instead of four; giving three replications of each variety, 27 replications of each level of phosphate and potash and 81 replications of each level of nitrogen.

As land used for this experiment in the previous season showed very great differences in fertility, a new piece of soil was selected for the experiment. This consisted of a light, grey sand, stumped and ploughed during the previous wet season.

Other details were as follows:—

Planted 14th December; refilled 24th December and 5th January.

Fertilizer was applied in three applications, as follows:—

$\frac{1}{3}$ before planting, $\frac{1}{3}$ on 8th January and $\frac{1}{3}$ on 20th January.

The stand was, on the whole, very good, and mosaic infection was slight.

Field Observations

There was a very marked difference in the rate of growth of plots having different levels of nitrogen, those with lower dressings being poorer in growth and paler in colour.

The mutual interdependence of nitrogen and phosphate was again very evident, more particularly in the early stages. Plots having lower dressings of phosphate grew more slowly than those with higher dressings, even when the level of nitrogen was high. The most striking examples were those having the highest level of nitrogen and the lowest level of phosphate. The plants in these plots were of a very dark green colour, but nevertheless grew very slowly, while those having the same level of nitrogen and a high dressing of phosphate grew very rapidly. As the crop matured, these differences became less obvious until towards reaping, when it was difficult to distinguish the various treatments in the field.

The results from this experiment are summarized in Tables I and II.

TABLE I

Treatment	Yield per acre lbs.	% of Mean	Price per lb. Pence	% of Mean	Value per acre			% of Mean
					£	s.	d.	
Jamaica Wrapper	1,073	105.7	9.72	99.6	43	10	0	105.2
Bonanza	964	94.9	9.80	100.4	39	9	0	95.4
White Stem Orinoco	1,008	99.3	9.76	100.0	41	2	0	99.4
16-lbs. p.a. P_2O_5	1,010	99.5	9.75	99.9	41	1	0	99.3
40-lbs. p.a. P_2O_5	1,026	101.1	9.79	100.3	41	18	0	98.7
64-lbs. p.a. P_2O_5	1,009	99.4	9.75	99.9	41	2	0	100.3
32-lbs. p.a. K_2O	1,024	100.9	9.78	100.2	41	15	0	101.0
48-lbs. p.a. K_2O	1,002	98.7	9.74	99.8	40	16	0	98.7
64-lbs. p.a. K_2O	1,019	100.4	9.76	100.0	41	10	0	100.3
18-lbs. p.a. N	940	92.6	9.55	97.8	37	10	0	90.7
27-lbs. p.a. N	1,024	100.9	9.80	100.4	41	16	0	101.1
36-lbs. p.a. N	1,081	106.5	9.94	101.8	44	14	0	108.1

	Yield	Price	Value
Mean of all treatments ..	1,015-lbs.	9.76d.	£41 7 0
Standard Error Variety	2.56%	2.02%	3.17%
Standard Error P_2O_5			
and K_2O	1.18%	1.17%	1.29%
Standard Error N ..	0.97%	0.42%	1.13%

Significant Difference N—

1%: 37-lbs. or 3.64%; 0.15d. or 1.54%; £1 15s. 0d. or 4.21%.

5%: 28-lbs. or 2.76%; 0.11d. or 1.13%; £1 6s. 0d. or 3.17%.

Summary of Significant Differences:—

At 5% point for yield, price and value—

27-lbs. nitrogen better than 18-lbs. nitrogen.

36-lbs nitrogen better than 18 or 27-lbs. nitrogen.

At 1% point for yield and value—

27-lbs. nitrogen better than 18-lbs. nitrogen.

36-lbs. nitrogen better than 18 or 27-lbs.

Price—

27 and 36-lbs. nitrogen better than 18-lbs. nitrogen.

Two-factor Interaction

The interaction between nitrogen and phosphorus was again significant on the basis of yield. Table II gives the results of this interaction :—

TABLE II

		N1		N2		N3	
		Yield per acre lbs.	% of Mean	Yield per acre lbs.	% of Mean	Yield per acre lbs.	% of Mean
P1	.. ..	952	93.8	1,038	102.3	1,041	102.6
P2	.. ..	943	92.9	1,036	102.1	1,098	108.2
P3	.. ..	927	91.3	997	98.2	1,103	108.7

Standard Error: 1.68%.

Significant Difference: 46-lbs. per acre or 4.6%.

Discussion of Results

Jamaica Wrapper again gave the highest yield, but the difference between varieties did not reach the level of significance. The three factor interaction between variety, nitrogen and potash, which was of significance in the 1943-44 season, was not significant, while on the basis of yield the three factor interaction between nitrogen, phosphate and variety was significant. In view of the difficulty of interpreting these results, any discussion must be left in abeyance until further data becomes available.

Phosphate and Nitrogen

These two factors again showed mutual inter-dependance. Taken independently, the results were as follows. Increasing the level of P_2O_5 from 16 to 64-lbs. per acre brought about no significant increase in yield, price or value. This was unexpected, as it seemed probable from the results of previous seasons that phosphate would have a marked effect on a new soil consisting of a very light sand. In the 1942-43 season also different levels of phosphate failed to show any effect on yield or quality, but that was a season of heavy rainfall, and the failure to produce results was attributed to loss of nitrogen, since the higher levels of phosphate can apparently only show their full effect in the presence of high nitrogen. No such heavy losses of nitrogen could have occurred with the low rainfall recorded during the season under review.

Each increase in the level of nitrogen has given a highly significant increase in yield, price and value, indicating that for this very light type of soil, on new land at least, an application of 36-lbs. per acre (equivalent to 600-lbs. per acre of Standard Fertilizer) is by no means excessive, even in a dry season.

In spite of the fact that phosphate alone showed no results, the interaction between phosphate and nitrogen was again significant. The results of this interaction, shown in Table II, agree closely with those of the previous seasons. With the first level of phosphate there is a significant increase in yield when the level of nitrogen is raised from 18 to 27-lbs., but 36-lbs. does not give a further significant increase.

With the second level of phosphate there is a significant increase in yield from the first to the second level of nitrogen and again to the third level. With the third level of phosphate the action of nitrogen is similar to the second level.

It is shown, therefore, that to obtain the maximum benefit from high dressings of nitrogen, it must be balanced by an adequate amount of phosphate. In this season again, a dressing of 40-lbs. per acre P_2O_5 was apparently sufficient to balance 36-lbs. per acre of nitrogen, as only a small increase in yield occurred when this level of nitrogen was combined with 64-lbs. P_2O_5 .

EXPERIMENT S.

The treatments tested in this experiment were three varieties, three levels of nitrogen and three levels of compost in all combinations, giving a total of 27 treatment types. The treatments were as follows:—

Variety					Nitrogen lbs. per acre	Compost tons per acre
V1	White Stem	Orinoco	....	....	N1 18	C1 0
V2	Bonanza	....	....	....	N2 27	C2 4
V3	Gold Dollar	....	....	....	N3 36	C3 8

The experiment was planted on 14th December; refilled 28th December.

The stand was very poor.

Nitrogen was applied as $\frac{1}{3}$ Nitrate of Soda, $\frac{1}{3}$ Ammonium Sulphate and $\frac{1}{3}$ Bloodmeal. Phosphate and potash were kept constant at 52-lbs. per acre and 32-lbs. per acre respectively.

The compost was applied round the marker and lightly covered.

Fertilizer was applied in three fractions: $\frac{1}{3}$ before planting, $\frac{1}{3}$ on 10th January and $\frac{1}{3}$ on 27th January.

The field used for the experiment consisted of a second-year land of very light sand, on which it was felt compost should show its maximum effect.

The results of the treatments are summarized in Table III.

TABLE III

Treatment		Yield per acre lbs.	% of Mean	Price per lb. Pence	% of Mean	Value per acre			% of Mean
						£	s.	d.	
White Stem	Orinoco	681	98.7	8.96	101.5	25	10	0	100.3
Bonanza	.....	738	107.0	8.74	99.0	26	19	0	106.1
Gold Dollar	.....	650	94.3	8.78	99.5	23	16	0	93.6
18-lbs. Nitrogen	per acre	655	94.9	8.82	99.9	24	2	0	94.8
27-lbs. Nitrogen	per acre	710	102.9	8.77	99.3	26	0	0	102.4
36-lbs. Nitrogen	per acre	704	102.2	8.89	100.8	26	3	0	102.8
0-tons Compost	per acre	694	100.6	8.72	98.8	25	5	0	99.4
4-tons Compost	per acre	673	97.5	8.88	100.6	24	19	0	98.1
8-tons Compost	per acre	702	101.9	8.88	100.6	26	1	0	102.5

Mean of all treatments ..	Yield	Price	Value
Standard Error ..	690-lbs.	8.83d.	£25 8 0
Significant Differences	3.37%	1.14%	3.94%
5% point :	68-lbs. or 9.8% ;	none ;	none.

Yield—

Bonanza better than Gold Dollar

Discussion

The results of this experiment were disappointing, the only significant difference being that Bonanza gave a better yield than Gold Dollar. This lack of significant differences must be attributed, in part at least, to the poor stand and uneven nature of the soil. These factors made the error of the experiment considerably higher than in the previous season, and environmental conditions have masked treatment effects. No deductions can be made, therefore, until the results are combined with those from other seasons.

EXPERIMENT R.

Previous experiments carried out between the years 1935 and 1939 had shown that in the majority of cases closer spacing produced a higher yield per acre. There was, at the same time, a definite relationship between closeness of spacing, time of maturity and percentage of bright leaf. The more plants per acre, the quicker the maturity and the brighter the leaf. In spite of the fact that both yield and cash return per acre could be materially increased by closing in the distance between plants, doubts were expressed as to the quality of the leaf produced. The percentage of "shorts" increased with the closer spacing, and much of the leaf although very bright lacked body and oil and was described by leaf experts as a "thin flashy type." While it was known, therefore, that the yield per acre could be increased by using a closer spacing, the strong emphasis placed on the necessity for producing body and quality in Rhodesian tobacco, if a permanent market was to be established, led to misgivings as to the real value of closer spacings.

Since these experiments were carried out, it has become the usual practice to apply fertilizer in two or more applications, and as this might have a marked effect on the quality of tobacco, it was felt that the whole question of spacing should be further investigated. An experiment was designed, therefore, to test the effects of different spacings and heights of topping in combination with three of the more widely grown varieties. The treatments selected were as follows:—

Spacing	Topping	Variety
3-ft. x 3-ft.	High	Jamaica Wrapper
3-ft. x 2-ft.	Low	White Stem Orinoco
3-ft. 6-in. x 2-ft.		Bonanza
4-ft. x 2-ft.		

High topping consisted of taking the head off just below the bud, and low topping five leaves lower down. All topping was carried out when approximately one or two flowers had opened.

A split plot arrangement was selected for the experiment. The spacings occupied the main plots, each main plot being split into six sub-plots to take the combinations of variety and topping. Each sub-plot was approximately 1/40th of an acre in extent. A new piece of land, opened and ploughed during the dry season, was chosen for the experiment. The soil type was a pink sandy loam. The field was planted on 14th December and refilled on 28th December, and 5th January, the final stand being good.

Fertilizer was applied as follows:—

Before planting: 150-lbs. per acre of a mixture of 100-lbs.
8-6-8 and 50-lbs. 20% Superphosphates.
13th January: 200-lbs. per acre 8-6-8.

The results of this experiment are summarized in Tables IV, V and VI. As there was no interaction between variety, spacing and topping treatments, each of these groups will be discussed separately.

TABLE IV.—SPACING TREATMENTS

Spacing	Yield per acre lbs.	% of Mean	Price per lb. Pence	% of Mean	Value per acre £ s. d.	% of Mean
3-ft. x 3-ft.	970	87.8	9.53	103.0	38 9 0	90.6
3-ft. x 2-ft.	1,233	111.6	9.04	97.9	46 8 0	109.3
3-ft. 6-in. x 2-ft.	1,151	104.1	9.17	99.1	43 18 0	103.4
4-ft. x 2-ft.	1,066	96.5	9.25	100.0	41 1 0	96.7

The Z test was significant at both 1% and 5% points.

	Yield	Price	Value
Mean	1,105-lbs.	9.25d.	£42 9 0
Standard Error	1.36%	0.30%	1.49%

Significant Difference—

1% point: 79-lbs. or 7.1%; none; £3 6s. 0d. or 7.8%.

5% point: 52-lbs. or 4.7%; 0.24d. or 2.6%; £2 4s. 0d. or 5.2%

Summary of Significant Differences:—

Yield at 5% and 1% points—

3-ft. x 2-ft. better than all other treatments.

3-ft. 6-in. x 2-ft. better than 3-ft. x 3-ft. or 4-ft. x 2-ft.

4-ft. x 2-ft. better than 3-ft. x 3-ft.

Value at 5% point—

3-ft. x 2-ft. better than all other treatments.

3-ft. 6-in. x 2-ft. better than 3-ft. x 3-ft. or 4-ft. x 2-ft.

4-ft. x 2-ft. better than 3-ft. x 3-ft.

Value at 1% point—

3-ft. x 2-ft. better than either 3-ft. x 3-ft. or 4-ft. x 2-ft.

3-ft. 6-in. x 2-ft. better than 3-ft. x 3-ft.

Price at 5% point—

3-ft. x 3-ft. better than all other treatments.

TABLE V

Spacing	Plants per acre Total	Plants per acre %	Yield per acre %	Value per acre %	Price per lb. %
3-ft. x 3-ft.	4,840	100	100	100	100
3-ft. x 2-ft.	7,260	150	127	121	95
3-ft. 6in. x 2-ft. ..	6,222	128	119	114	96
4-ft. x 2-ft.	5,445	112	110	107	97

Discussion of Results of Spacings

The results of the spacing trials are, on the whole, in accord with the findings of previous experiments mentioned above. Each of the closer spacings has given a better return on yield and value than the standard 3-ft. x 3-ft., but there was a drop in quality in each case, the 3-ft. x 3-ft. spacing giving a better price than any of the other spacings. There was a noticeably higher percentage of short grades in the closer spacings, the proportion increasing with the number of plants per acre. In Table V the results from the spacing trials are further analysed. This Table gives the number of plants per acre and the percentage plants per acre, yield, price and value taking 3-ft. x 3-ft. as a standard. It will be noticed that, while the closest spacing gives 50% more plants per acre compared with the standard, the increase in yield and value are 27% and 21% respectively. As the spacing widens, the disproportion between yield and value and plants per acre lessens and the price per pound rises.

In favour of the closer spacing are, therefore, the facts that the yield and value are materially increased compared with standard spacing; while against it are the lower price per pound and the higher costs of working per acre due to increased fertilizer and the lower returns of leaf per plant. To what extent the pros and cons of closer spacing can be balanced on a commercial scale, would seem to depend largely on the state of the market and soil type. On certain soil types where tobacco tends to grow rank, closer spacing should produce a brighter type of leaf, provided it does not render the crop more susceptible to disease. Spacing trials carried out on heavy soils to decide these points should yield valuable results. On the lighter sands, where good quality leaf can be produced at the standard spacing, it is doubtful whether increased yield, at the expense of quality, is a good policy in the long run. Seasonal conditions will probably have a marked effect; in the majority of seasons in which spacing trials have been carried out, conditions were favourable to good growth, and all trials were on the better soils of the Station. In seasons when growth is more feeble, and on the weaker soils, different results may be obtained from those obtaining in good years.

TABLE VI.—TOPPING TREATMENTS

Treatment		Yield		Price		Value		
		per acre lbs.	% of Mean	per acre Pence	% of Mean	per acre £ s. d.	% of Mean	
High Topping	.....	1,149	104.0	9.17	99.1	43 16 0	103.2	
Low Topping	.....	1,060	96.0	9.33	100.9	41 2 0	96.8	

	Yield	Price	Value
Mean of all treatments ..	1,105-lbs	9.25d.	£42 9 0
Standard Error	1.59%	0.21%	1.67%

Significant Difference—

5%: 50-lbs. or 4.5%; 0.14d. or 1.5% £2 2s. 0d. or 4.9%.

1%: 68-lbs. or 6.1%; none; none.

Summary of Significant Differences:—

Yield, 5% and 1% points—

High topping better than low topping.

Value, 5% point—

High topping better than low topping.

Price, 5% point—

Low topping better than high topping.

Discussion of Results of Topping Treatment.

The removal of five leaves, as was the case in the low topping treatment, brought about a significant decrease in yield and value. The low topping, on the other hand, gave a significantly higher price per pound. An examination of the leaf from each treatment showed no intrinsic differences in quality. It seems more than likely that the lower price per pound in the high topping is due solely to a greater percentage of shorts than in the low topping treatment, where the short top leaves were removed. It may be noted here that all previous experiments have shown that the time of topping is more important than the height, early topping giving better results than late.

Varietal Results

The yields, prices and values from the three varieties in this experiment are summarized in Table VII.

TABLE VII.—VARIETIES

Variety	Yield per acre lbs.	% of Mean	Price per lb. Pence	% of Mean	Value			% of Mean
					£	s.	d.	
Jamaica Wrapper	1,163	105.2	9.16	99.0	44	4	0	104.2
White Stem Orinoco	1,106	100.1	9.16	99.0	42	3	0	99.3
Bonanza	1,046	94.7	9.42	102.0	41	0	0	96.5

	Yield	Price	Value
Mean of all varieties	1,105-lbs.	9.25d.	£42 9 0
Standard Error	1.51%	0.35%	2.13%
Significant Differences	5% : 49-lbs. or 4.4% ; 0.23d. or 2.5% ; none. 1% : 66-lbs. or 6.0% ; none ; none.		

Summary of Significant Differences:—

Yield at 5% point—

Jamaica Wrapper better than White Stem Orinoco or Bonanza.
White Stem Orinoco better than Bonanza.

Yield at 1% point—

Jamaica Wrapper better than Bonanza.

Price at 5% point—

Bonanza better than Jamaica Wrapper or White Stem Orinoco.

Discussion of Results

Jamaica Wrapper again proved the most vigorous of the three varieties, with White Stem Orinoco second, both giving significantly better yields than Bonanza. Bonanza, on the other hand, gave a significantly higher price than either White Stem or Jamaica Wrapper. The difference in value did not reach the level of significance. The behaviour of the varieties was in accordance with what was expected from results obtained over a number of years. There was no interaction between the varieties and the topping and spacing treatments, indicating that there was no differential response to these treatments.

V—Diseases

Leaf diseases of tobacco are normally associated with warm, humid conditions, particularly if these conditions remain unbroken for several weeks at a time during the growing season. This has been a dry season on the Station, and the rainfall was well distributed, with the consequence that bacterial diseases were of no importance, and the leaf-spotting diseases due to fungi of only minor importance. Barn rot (*Rhizopus nigricans* Ehrcub.) was troublesome, especially in the early and middle reapings from certain fields on the Station.

Loss due to virus diseases was small.

VIRUS DISEASES

TOBACCO MOSAIC

The only control measure employed was the thorough washing of hands prior to handling plants in the seedbeds and in the field until the first reaping. Infected plants were handled separately. The control achieved was good, and was of the same order as that obtained since the 1938-1939 season. The percentage of mosaic plants six weeks after planting out ranged from 0.3% to 1.1%, with the exception of one field of four acres (variety trials).

The variety trials, consisting of 25 varieties and selections, gave an average at six weeks of 2.7% mosaic. A count was made on the six replications of each selection, and it was found that three selections averaged between 8% to 14.5%; eight averaged 2% to 3%; five averaged 1% to 1.9% and seven below 1%. In the three selections in which the percentage of mosaic-infected plants was high, the infected plants were spread fairly evenly throughout the replications. Each selection was planted out separately, and hands were not washed between the planting of one selection and the next. It would seem that infection had been introduced into the seedbeds of these three selections during weeding. After planting one of them there would be come carry-over of virus on the hands of the labourers to the next selection planted. This would account for the moderately high percentage (2% to 3%) of infected plants in certain of the other selections.

MOSAIC RESISTANCE

Breeding for mosaic resistance was continued using (a) glutinosa-type resistance and (b) Ambalema type.

(a) To date, seven back crosses to Bonanza have been made from the original Burley-digluta hybrid obtained from F. O. Holmes, of the Rockefeller Institute, Princeton, N.J. Last season the N-type Bonanza was selfed and some 500 seedlings were grown and set out in the field this year. When inoculated with mosaic they gave the expected 3 : 1 ratio of necrotic to systemic type plants. The latter were rogued. The remaining plants grew out fairly well, and twelve of the most vigorous were bagged. Seed from these selfed plants when tested gave two double dominants and ten single dominants.

Backcrosses were made to Bonanza, Jamaica Wrapper and White Stem Orinoco (Greenville strain). Leaf from the necrotic type plants was cured and graded. It cured out well, and in colour, feel and odour was indistinguishable from Bonanza. There was insufficient for smoking tests.

(b) Seed sown from three selfed plants with the following history: Ambalema X Jamaica Wrapper back crossed to Jamaica Wrapper, selfed, and resistants crossed to Jamaica Wrapper, and selfed again: gave fourteen immunes from approximately 350 seedlings in one family and no immunes in the other two families. The immunes were very similar in growth, type and leaf shape, and exhibited none of the twisting characteristics of Ambalema. At the same time, they could easily be distinguished from the normal flue-cured varieties. Ten of the immune plants were crossed on to White Stem Orinoco.

ROSETTE DISEASE

The incidence of Rosette disease was low, and aphid did not reach sufficiently high numbers on the Virginian crop to be serious.

A NEW VIRUS(?) DISEASE

Tobacco planted on 24th November was found on 4th January to contain a group of several hundred plants with three to four unusual lesions on their leaves. The lesions were one-quarter to one-half inch in diameter, chlorotic with a tendency to ring formation. The edge of the ring or rings was often etched with small necrotic flecks. Where rings were distinct, they were made up of alternating yellowish and greenish bands. As the lesions increased in size, they tended to follow the veins (or vein), and spread slowly along them, usually causing them to die. In older lesions, the rings disappeared, leaving a large, chlorotic spot flecked with pin-point, white dead areas.

Most of the lesions were confined to leaves produced before the first fortnight in January. Only occasional lesions were found in leaves produced later. The disease did not become systemic, and there was no effect upon the growth of the plant. Leaves attacked when young showed some distortion and tearing with growth.

The nature of the lesions suggested that they were of virus origin, and a search for possible virus diseases in weeds in the neighbourhood of the affected plants revealed a patch of *Solanum panduraciforme* on the contour ridge extending for about 30 yards. Almost all the *Solanum* plants were affected with a disease causing an indistinct yellow mottling of the leaves with occasional distinct chlorotic rings. There was some twisting and distortion of the leaves, which were smaller than normal leaves.

Two more groups of diseased *Solanum* plants were found in other fields. One group was on the edge of a field planted on 24th November. The tobacco adjacent to it was affected, the numbers affected decreasing until about 50 yards from the *Solanum* no further plants with lesions were found.

The second area of affected *Solanum* was on an antheap, in a field planted on 28th December. Only a few plants were affected, with a total of some ten lesions. The disease in tobacco was seen only once off the Station, in a field of early tobacco. Again, infected *Solanum* plants were found nearby.

Inoculation Tests

An inoculum was prepared by grinding up lesions from tobacco leaves with fine carborundum powder. It was then rubbed on to the leaves of twelve tobacco seedlings kept in pots in the greenhouse. None of the test seedlings developed lesions within six weeks.

Possible Insect Vectors

A month after the disease was noticed, a search of the diseased *Solanum* was made for possible insect vectors. Two species of Jassids, one species of Sarcofid and one species of Capsid were collected. When tested in cages with tobacco seedlings, none transmitted the disease.

It is possible that other insects were responsible for the spread, but that they disappeared from the *Solanum* early in the season. There is some slight evidence that this may have been the case from the observation that in late planted tobacco, adjoining an area of diseased *Solanum*, only a very few lesions were found. In the early planted tobacco, only occasional new lesions occurred in the latter half of January. The agent spreading the disease had largely disappeared by mid-season.

So far, no proof is available that the disease in tobacco was caused by the same agent as the disease in *Solanum*, but there is strong circumstantial evidence for connecting the two.

Practical Aspects

The disease has not been observed previously in tobacco, although diseased *Solanum* plants were seen in 1939. It is, therefore, felt that the disease is unlikely to occur regularly or cause serious damage. The damage caused this season was confined to two small areas, and was slight even within those areas.

BACTERIAL DISEASES

The spread of bacterial diseases in tobacco is governed mainly by the distribution and intensity of rainfall. The season under review was dry, and did not favour the spread of angular leaf spot or wildfire.

Angular leaf spot was not observed in seedbeds, but by the second week in February three isolated plants with Angular were found in one field that had carried a tobacco crop the previous year. With the beginning of the rainy spell in February, Angular began to appear in groups of three to five plants in widely separated fields. Three of the groups were found in new land planted with seedlings that showed no trace of the disease. How the infection was introduced into the new land is unknown. A possible explanation is to be found in recent American work (Valleau, W. D., Johnson, E. M., and Diachun, Stephen. *Root Infection of Crop Plants and Weeds by Tobacco Leaf-Spot Bacteria*. Phytopath. 34: 163-174, 1944). They have demonstrated that the bacteria causing angular and wildfire are frequently associated with the roots of certain crop plants and weeds, including tobacco, where they may live for many years as part of the normal soil flora. In tobacco, it is only under certain conditions that the bacteria will attack the leaves. Seedbeds in which no disease was seen on the leaves were found frequently to have large numbers of the organisms associated with the roots.

In Kentucky, the spray schedule recommended for seedbeds does not aim to keep the leaves covered with a protective film of fungicide, but to cover the surface of the soil. They state that both diseases can be

completely controlled in the beds by two applications of Bordeaux mixture to the surface of the soil when the plants are small, the purpose of the second application being to make certain the soil coverage is complete.

FUNGUS DISEASES

WHITE MOULD (*Erysiphe chioracearum* DC)

The varieties of flue-cured tobacco now grown in the Colony are resistant to white mould under the conditions which normally prevail during the growing season. Dry conditions, combined with vigorous plant growth, favour the disease. This season, where tobacco was "heavy," white mould developed on the lower leaves, many of which were damaged. Jamaica Wrapper appeared to be more susceptible than the other varieties grown, but since it is a very vigorous variety and tends to produce a "heavier" plant, its greater susceptibility may well be due to this. Where Jamaica Wrapper did not make rank growth, it was free of the disease.

After the third picking, white mould ceased to be of any consequence, even in the heaviest tobacco grown.

ALTERARIA LEAF SPOT [*Alternaria longipes* (Ell. & Ev.) Mason]

All the experiments on leaf-spotting diseases were placed in a field in which the tobacco had been damaged in the previous season by alternaria leaf spot. The dry season was unfavourable for the fungus, and only very occasional lesions were observed in these plots late in the season. At the time of the first reaping, alternaria had not appeared.

Alternaria lesions were observed in some of the other fields on the Station about the eighth week after plants were set out. The numbers decreased as the season progressed, and only very occasional top leaves were affected.

Alternaria has become a serious disease of Virginia tobacco within the last decade. Hopkins (*Diseases of Tobacco in Southern Rhodesia*, 1931) says of it: "The disease has not been known to cause serious damage, but, on occasion, it may put an appreciable amount of otherwise good leaf into the perished grades." Serious outbreaks of the disease are practically confined to areas in which flue-cured is grown on "contact" or fine, sandy soils derived from sources other than granite. It is a disease of only occasional importance on the granitic sands. The records of the Research Station are cited to substantiate this statement. Over the last ten years, alternaria has caused serious damage in one season (1943-1944) and then only in one field, where it was estimated to have reduced the value of the crop from that field by 30% to 40%. The field in question represents the heaviest soil on the Station, a pink sand underlain by quartz pebbles. This was the second crop of tobacco in succession. The average rainfall for the past ten years was almost 38 inches.

Except for the instance mentioned, the damage done by alternaria here has been slight.

BARN ROT (*Rhizopus nigricans*)

Barn rot has been troublesome during the past season, and occasioned some loss of leaf on the Station. Reports from growers, however, indicate that it has caused heavy losses throughout the tobacco-growing districts.

Attempts were made to determine the factors influencing the incidence of barn rot, both during curing and in the lands. From observations and experiments, the following points emerged:—

(1) Individual barns exert an effect on the production of the disease. For example, the fifth picking (no rot in early pickings) from the seed-bulking field was packed in barns 9 and 10. Barns were packed at the same rate, fairly tightly, and treated throughout the curing in the same way. Vents were opened at 110°F, seventy hours after the barns went in, and the temperature was raised by 10° intervals to 140° in the following twenty-four hours. When the barns were taken down, practically every stick in No. 9 barn had barn rot, while the disease was slight in No. 10.

Again, in the fourth picking of the N, P, K trials, the leaf was put into three small barns. Barns were cured in an identical manner, temperatures moved at the same time and vents opened at the same time. In one barn, practically every stick had barn rot; in the second, about one-half of the sticks were affected, while the third barn was practically free.

(2) If one picking from a field had barn rot, it did not follow that subsequent pickings would have it.

(3) Spores of *Rhizopus nigricans* are not killed during drying of the midrib. A germination test from spores from a stick hanging next to the thermometer was made immediately after the midribs were dried at 160°F for sixty hours. Most of the spores germinated in twenty-four hours at room temperature.

(4) Spraying the barn out with a copper fungicide, and soaking all sticks and string in the fungicide did not appear to reduce, and certainly did not eliminate, barn rot. One grower writes: "I have, this season, cured tobacco in new barns with new sticks and string with no better results than in old barns."

(5) Tying the leaves in fives did not increase the amount of barn rot against tying three leaves together.

(6) Barn rot seldom starts at the broken end of the butt. It usually starts near the string, spreading both up and down from the string. Sometimes in a hand of three leaves, one leaf may escape infection though tied against two rotting butts. It was at first thought that bruising of the midribs was important, but various methods designed to lessen the bruising did not reduce the disease.

(7) Heavier types of leaf seemed to be less susceptible than medium and light leaf.

(8) Lightly packed barns could be fixed and dried more quickly than tightly packed barns, and this reduced the damage from barn rot.

(9) Yellowing at 90°F, no sign of barn rot has been observed forty-eight hours from the start of a barn. At sixty hours, the disease is noticed as a slime on the butts in the region of the string, though it occasionally begins in the web, where a leaf has been torn or folded. If, at this stage, the temperature is raised gradually to 140°F, leaf will be severely damaged. If, however, on observing the slimy butts at sixty hours, vents are opened immediately and the temperature is raised by

10° at two-hourly intervals up to 140°F and held there until the web is dry, the rot will be practically confined to the butt end of the midrib. The amount of sponged leaf did not seem to be increased by quick fixing.

Discussion

Information on the incidence of barn rot and methods of curing, etc., was sought from growers whenever possible. Many growers stated: "We usually get barn rot in the early part of the season and then it practically disappears." A possible explanation is that most growers have one barn for approximately every ten acres of tobacco. If the crop grows out well, about 10,000-lbs. will have to be cured per barn. To cope with this amount, the tendency is to take the early reappings on the green side, but as the season progresses the leaf ripens faster than barn accommodation becomes available; consequently, the time necessary to yellow is appreciably decreased, and, as the barn is wanted again, it will be fixed as rapidly as the individual grower feels it is safe to hurry the process. Where a grower has sufficient accommodation to pick when he likes, it is usual to pick slightly on the green side, particularly if barn spot has appeared.

Bearing in mind the above paragraph and the fact that the rot takes between forty-eight and sixty hours to appear, it should be feasible to control the disease by reaping leaf that will yellow in forty-eight hours or less, and then fixing it fairly rapidly. At 120°F the mould will have ceased growth, but it must be remembered that when the thermometer reads 120°F, the temperature of the top and corners of the barn may be considerably less. It is as well to watch the corners closely, and, if necessary, raise the temperature fairly rapidly to 140°F. We have been able to keep the disease in check by these means.

Why some barns tend to produce the disease more readily than others is not known. A suggestion has come from growers that barns with leaky flues tend to be free from barn rot, and that charcoal braziers in the barn have a similar effect. The effect is ascribed to the carbon monoxide produced in wood fuel gases. Studies have been made on the effect of CO on the growth of *R.nigricans* in connection with the preservation of foodstuffs. (Rev. appl. Myc. 1934. P.118). The conclusions reached are that the gas in the presence of high oxygen concentrations, as found in air, retard the growth rate only slightly, but that if the CO/O₂ ratio is high, the effect on the mould is considerably greater. Charcoal braziers have not been tried in the Station barns. Flues of those barns that did not readily produce the disease (see para. 1) were examined and found to be in good order. No leaks were detected. The barns concerned did seem to be less airtight, a factor which would reduce the relative humidity of the barn atmosphere in sunny weather and may be important.

Further discussion of the barn factors in barn rot will not be profitable until these are better understood. Any information from growers of their experiences with barn rot will be welcomed.

FROG EYE (*Cercospora nicotianae* Ell. & Ev.)

General Observations:

(a) Seedbeds

The Station seedbeds were free from frog eye until the middle of December. At about the third week in December, beds that had been

pulled over earlier and abandoned, developed the disease extensively, almost all the plants being infected. Very occasional frog eye lesions developed in beds that had not been used.

The seedbed site had not been used for two seasons; the soil had been sterilized by burning a thick layer of brushwood, and all seed sown had been cleaned and sterilized with 1:1,000 Silver Nitrate. New bricks were used to edge the bed and seedbed cloth was sterilized by boiling. Seedlings were sprayed twice with Perenox.

It is difficult to understand how the disease was introduced unless large numbers of spores were blown in. It has been noticed in past years that whenever seedlings turn yellow and regular spraying has ceased, frog eye develops rapidly and extensively, even in the dry atmosphere of October and November. This point is worth remembering in connection with barn spot, which may appear in one or more reapings from a field of tobacco in which few frog eye lesions have been seen.

(b) *Field Observations*

Tobacco planted out on the Station before the middle of December was from beds in which no frog eye lesions were found. Some ten acres were set out on 24th November in a field which had not carried tobacco for six years. Frog eye lesions were not seen until the first week in January, when a few were found on the yellowing, bottom leaves. By the end of January, lesions were plentiful on lower leaves. Many were atypical, large ($\frac{1}{2}$ -inch diameter) and dark brown with a tendency to be zonate but without the typical white centre. They produced few spores. In many instances they resembled lesions produced by *Alternaria*. Such atypical lesions are known to occur under dry conditions.

A field that had not carried tobacco for six years, and was planted early with clean seedlings, developed frog eye as the lower leaves turned yellow and became susceptible. It is difficult to escape the conclusion that, at least in the older tobacco-growing districts, whenever the leaf becomes susceptible and weather conditions are suitable, frog eye will appear.

Another interesting case occurred in two fields separated by a drain. One field was carrying its second successive crop of tobacco following three years Rhodes grass; the other was new land. Both were planted on 1st December, 1944, and by the time of the first reaping the tobacco in both fields had about the same density of frog eye spots on their lower leaves. No barn spot developed in the first reaping. In the second reaping, picked on the same day and cured in the same barn, tobacco from the second-year land was damaged by barn spot, whilst there was no barn spot in tobacco from the first-year land. In the third reaping, there was some barn spot from the second-year land, but it did not appear in subsequent reapings. The first-year land showed no barn spot in any reapings. Both fields yielded approximately 1,000 lbs. to the acre.

Ample inoculum was present in both fields; weather conditions were the same for both so that one must conclude that the leaf was more susceptible to infection in the second-year land.

The tobacco planted at the end of December was in three widely separated fields: (a) fertilizer trials on first-year land; (b) time and method of application of compost on second-year land and (c) disease experiments on third-year land. Frog eye developed in all the fields.

The first and second reapings were taken on the same day on each occasion, and the tobacco was cured together. In the first reaping, all were free from barn spot. In the second reaping, all were more or less equally affected by it. Subsequently, it practically disappeared from (a) and (c), but (b) was damaged in every reaping. (b) was the only field that showed marked secondary growth.

The percentage of spotted leaf in the second reaping of the fertilizer trials and of the rate and method of application of compost did not show any significant difference in either experiment, between the amount of spot in the various treatments. None of the treatments concerned could be said to have increased or reduced the resistance of the leaf in the second picking of the above experiments. The continued susceptibility of the leaf to barn spot in the rate and method of application of compost experiment was thought to be due to the secondary growth that occurred in this field.

In sorting the cured leaf of the second picking of the late tobacco, it was not unusual to find in, say, three sticks from a plot that two were badly spotted, whilst the third was almost free of barn spot. This would suggest that the position in the barn was sometimes important in the production of the disease.

Summary

(1) Frog eye appears in seedbeds as soon as plants become susceptible and regular spraying has ceased, despite all other precautions to exclude it, i.e. sterilization of seed, soil, bricks and cloth.

(2) In new or "reverted" lands, planted with apparently clean seedlings, lesions begin on the lower leaves when they start turning colour.

(3) There was no correlation between the density of frog eye infection prior to the first reaping and the production of barn spot.

(4) Barn spot occurred in leaf from certain fields; other fields (one adjacent) planted at the same time, were free or almost free of barn spot. The reason for this is not known, though in one case secondary growth appeared to be the determining factor.

(5) Over a fair range of fertilizer and compost trials, no treatment appeared to affect the production of barn spot.

Is Frog Eye Windborne?

A test was carried out to see whether frog eye spores would infect a small, isolated group of tobacco plants grown some 500 yards from the nearest tobacco.

An area 5 yards by 10 yards was selected in the corner of a field that had not grown tobacco for eight years. No tobacco had been grown within half a mile of the field for some years and the nearest centre of tobacco was at the barns, approximately 500 yards away.

Fifty plants were pulled from the beds on 16th December, 1944. None showed any frog eye lesions. The plants were immersed in a solution of Perenox for five minutes and then planted out. Only six plants survived the treatment, and the sunny weather that followed planting out. Plants were examined at weekly intervals in the mornings, before other fields were visited to reduce the chance of carrying in spores.

The first frog eye spot was found on one of the plants on the 16th February, 1945, two months after they had been planted out. Subsequently, lesions appeared on all the plants, including one *Alternaria* lesion.

Conclusion

It would seem that both frog eye and *Alternaria* spores can be carried over distances of at least 500 yards.

EXPERIMENTS ON LEAF-SPOTTING DISEASES CAUSED BY FUNGI

The experiments to be described were laid down to ascertain the effects of certain treatments on the incidence of fungus diseases in the field and in the barn.

The field chosen for the experiments was a heavy, pink sand, underlain by quartz rubble. It had carried two successive crops of tobacco. The crop last year from it had been severely damaged by *Alternaria*.

All experiments were planted on 28th December and refilled on 5th January.

Alternaria leaf spot did not develop and no bacterial diseases were seen. The results recorded refer only to frog eye and its phase in the barns (barn spot).

REAPING EXPERIMENT

The object of the experiment was to test whether the degree of ripeness of the leaf was an important factor in the production of barn spot.

The tobacco grew out well initially and was not primed until the first picking at the end of the eighth week in the field, by which time frog eye was general on the lower leaves. All ripe leaf was taken in the first picking to even up the degree of ripeness of the plots, some of which were well grown while others were poor.

The second picking taken a week later was a differential picking. Treatments were:

- (1) 2 leaves reaped per plant;
- (2) 3 leaves reaped per plant;
- (3) 4 leaves reaped per plant;
- (4) 5 leaves reaped per plant.

Treatments were randomized with five replications.

At the time of the second picking, there were three to four leaves ripe per plant so that treatment (2) represented a normal picking. All were cured in the same barn together with other experimental tobacco.

Twelve days later, when the plots from which five leaves had been reaped were again ripe, a third reaping was made and all ripe leaf was picked. Treatment (1) had five to six ripe leaves per plant, while (4) had two to three.

The fourth and fifth were normal pickings. This was done to see if any treatment effects were carried over.

Results were calculated on the percentage "spotted" leaf per plot per reaping. The mean percentage "spotted" leaf per treatment is given below. Significant differences were found in the third reaping, a

difference of 18.7 between means being significant, and in the combination of second and third reapings where a difference in means of 16.9 is significant at the 5% point.

Treatment					Mean Percentage " Spotted " Leaf per Reaping					
					Reapings:					All
					1st	2nd	3rd	4th	2nd & 3rd	
1	..	..	..	..	42.4	48.6	43.6	13.6	44.6	37.2
2	..	..	..	..	36.2	28.4	24.6	18.6	26.4	25.0
3	..	..	..	..	42.6	37.0	23.2	18.6	30.2	29.8
4	..	..	..	..	31.6	24.8	7.8	10.0	18.8	19.2

Significant (18.7) at 5% point; Significant (16.9) at 5% point; almost significant.

First Reaping

Variation within treatments was large and the difference between treatments was not significant. This is to be expected as all treatments had so far been treated alike.

Second Reaping

This was the differential reaping. Though there is still no significance, it is of interest to note that where only two leaves per plant were reaped, the mean percentage of "spot" has increased slightly, whereas it has decreased where three or more leaves were reaped.

Third Reaping

Here the leaf was again ripest in treatment (1) and progressively less ripe in (2), (3) and (4). A difference between means of 18.7 is significant at the 5% point, thus treatments (2), (3) and (4) are better than (1). Treatment (4) is almost better than (2) and (3). In treatment (1), the percentage spotted leaf has remained fairly constant over the first three reapings, whereas there has been a progressive decrease in the other treatments.

Fourth Reaping

The general level of spot fell considerably throughout the experiment and no effect of the earlier treatments was apparent.

Second and Third Reapings Combined

The difference in mean percentage spot of 16.9 is significant at the 5% point. Treatments (2) and (4) are better than (1), whilst (3) is almost better than (1). Treatment (3) had a high initial spot value.

Green Grades

The percentage of green grades over the second and third reapings was:—

- (1) 1.5%
- (2) 6.0%
- (3) 8.0%
- (4) 15.0%

The green grades were made up of saleable leaf, and fell into the standard classification of CGG mostly, with some MG.

Discussion

Under the conditions of the experiment, the riper the leaf, the greater was the tendency to develop barn spot. This may have been due either to the longer period the leaf remained on the plant after ripening, or to the longer period in the barn after the leaf yellowed and before the colour was fixed, or to a combination of these factors. Since all treatments were cured together, the riper leaf had to wait for fixing until the barn as a whole was ready. To separate field from possible barn factors, it will be necessary to grow sufficient tobacco in any one treatment so that the leaf from that treatment can be cured separately.

Considering both barn spot and barn rot, it would seem that reaping on the green side tends to reduce the former but may lead to severe damage by the latter. The decision to reap on the green side, or on the ripe side, will depend on the relative severity of these two diseases in any particular season or crop.

It may be mentioned here that it has been noticed on several occasions that when leaf, reaped on the green side, has developed barn spot, the amount of spotting has sometimes been reduced by allowing the leaf to ripen properly in the field. This may have been due either to the shorter yellowing period in the barn, or to passing from favourable weather conditions for the production of the disease, to unfavourable conditions. It is not uncommon to get barn spot in only one or two reapings from a field.

PRIMING EXPERIMENT

This is a continuation of previous experiments designed to test the effect of priming at three to four weeks after planting out on the incidence of frog eye and barn spot, and on yield and quality of leaf.

Treatments were:—

- (1) Unprimed;
- (2) Moderately primed (seedling leaves removed);
- (3) Primed to the bud (leaving only bud leaves).

The experiment was laid out in randomized blocks with seven replications. It was planted on 28th December and refiled on 5th January. All treatments were fertilized with 100-lbs. Standard Mixture before planting, followed by 100-lbs. on 22nd January, 1945.

Priming was done on 2nd February. Up to this stage, all plots had made good growth, and, except for very occasional frog eye lesions, were disease free. There was only one mosaic plant in the whole experiment. The final stand was poor, and a stand count, after priming, gave the following results:—

- (1) 66%; (2) 73.5%; (3) 70%.

Following priming, plots in treatments (1) and (2) continued to grow normally. There was no apparent setback, except that treatment (1) plots came into flower four to five days ahead of treatment (2). In the heavily primed plots there was a marked setback, more so than in any previous trial, and the plots were distinguishable by their poor growth throughout the duration of the experiment.

Except for some frog eye and a very occasional alternaria lesion, no other disease developed.

Results:—

	Yield in lbs. per 1/40th acre plot: Blocks:								
Treatments	A	B	C	D	E	F	G	Total	Mean
1	15.93	15.06	21.38	18.69	11.13	14.63	15.81	112.63	16.09
2	24.06	20.13	16.87	16.06	13.44	15.69	15.69	121.94	17.42
3	8.50	9.19	10.69	12.38	8.93	5.44	4.63	59.76	8.54

A difference in means of 3.22-lbs. is significant at the 1% point. Not priming and moderate priming at four weeks after planting out showed no difference in final yield, and both gave a significantly better yield than priming to the bud.

There was no significant differences in the percentage "spotted" leaf per treatment. The mean percentage was (1) 30.5%, (2) 36.3% and (3) 34.7%.

Discussion

Previous trials have always given a slight decrease in yield with heavy priming. The startling decrease this season illustrates the danger of severe priming in certain years.

Barn spot did occur to some extent in the earlier reapings, but was not severe. No effect could be detected, between treatments, on the production of barn spot. It should, however, be pointed out that for statistical purposes, the plots were grouped together. The theory of priming early is that the susceptible lower leaves are removed before the fungus forms spores, and so reduces the chance of infection later (see seedbed and field observations on frog eye). When unprimed plots are grouped with primed plots, this theory cannot be adequately tested.

EFFECT OF RATE AND TIME OF APPLICATION OF FERTILIZER ON LEAF DISEASES

This experiment was laid down on a heavy, pink sand that had carried one previous crop of tobacco, and adjoined the field in which alternaria had been severe last season. All fertilizer was applied as Standard Mixture. Treatments were:—

	Before Planting			3 Weeks after Planting	5 Weeks after Planting
(1)	..	..	..	100-lbs. p.a.	—
(2)	..	..	..	100-lbs. p.a.	—
(3)	..	..	..	100-lbs. p.a.	100-lbs. p.a.
(4)	..	..	..	100-lbs. p.a.	100-lbs. p.a.
(5)	..	..	..	100-lbs. p.a.	200-lbs. p.a.
(6)	..	..	..	100-lbs. p.a.	250-lbs. p.a.

These treatments were selected with the following objects in mind. Treatment (1) was expected to give good initial growth, but checking at about the fourth week. In (2) the check to growth was expected later. In (3) it was hoped that the plants would check, and secondary growth

be induced at about the sixth week. (4) was expected to give good, steady growth, while in (5) and (6) the plants would continue growing vigorously, and ripening would be seriously delayed.

The experiment was laid out in randomized blocks with five replications.

Field Notes

Plants came away well in all treatments, but the stand was seriously impaired by white grubs, and a final count of only 70% was recorded. Conditions remained favourable for good growth and, contrary to expectations, all plots grew out well and no instance of a check to growth was observed. The plants in (5) and (6) ripened more slowly than in the other treatments. The experiment was practically disease free, except for some frog eye lesions and occasional patches of white mould where the growth was heavy. Very occasional alternaria lesions were observed.

Results

The mean yield for the whole experiment was 820-lbs. per acre. There was no significant differences between treatments in yield or value. The quality of the leaf was good, with an average price of 8.48 pence per lb. (Standard values).

Under the dry, but favourable growing conditions the rate and time of application of fertilizer failed to produce the expected differences in growth. Leaf diseases did not develop.

VI—Root Knot Nematode

FIELD EXPERIMENTS IN CONTROL

The field trials concerned with the control of root knot nematode have been continued on the infested land on Thurbar Farm in accordance with the original plan.

The following descriptions of different sections of this land are necessary for a full understanding of this report:—

“ X ” LAND

This section was ploughed up in 1942, after it had lain for several years in weed fallow, and rotations and other trials were started immediately. It was anticipated that the nematode density would be only moderate, and this has proved to be the case. Sixteen plots planted to tobacco the first year showed an average infestation of 41.3%.

“ Y ” LAND

This section is similar in history to the “ X ” land, except that it remained in weed fallow for two more years, being ploughed up in 1944. The infestation has proved to be higher than was expected, exceeding anything recorded in the “ X ” section in the first season after ploughing up.

“ Z ” LAND

This section was broken from weed fallow in 1942, and, as very high nematode density was required for certain trials, the first season was devoted to building up the nematode population in the soil. The whole section was planted with tobacco, using infested seedlings as far as possible and infested soil from elsewhere was inserted close to each plant. A survey of the infestation at the end of the season showed it to be high and generally distributed. The growing of the tobacco crop should, of course, have increased it still further. The nematode density in this section has, in fact, proved to have been very high indeed.

The following notes refer to the past year:—

With the exception of the plots which were under *dhal* or had been left to weed fallow, the whole land used for the trials was free from crop remnants and weeds throughout the dry season, dating from the end of April. Many living roots of forest trees, chiefly Mnondo (*Isoberlinia globiflora*) were found, however, to persist in spite of systematic and frequent removal of shoots and of as much of the roots as was practicable.

The variety of tobacco used for all the trials was *Bonanza*.

Unless otherwise stated in connection with any particular trial, all the plots carrying tobacco during the growing season were planted and filled in on the same dates and received the same applications of fertilizer. Only Standard Fertilizer was used. With a similar reservation, all the plots were *ridged* for planting.

Planting and filling in dates were: 24th November, 1st December, and 15th December.

Dates and quantities of fertilizer applications were: 29th November, 100-lbs. p.a.; 20th or 21st December, 200-lbs. p.a. Total, 300-lbs. Standard Fertilizer per acre.

Except in a few stated instances, the fertilizer was applied in a ring round the plant and was lightly worked into the soil.

The infestation of the tobacco plants was recorded at maturity, i.e., after harvest. The basis of the classification is: *Heavy*—over 50% of the roots galled; *Medium*—25% to 50% of the roots galled; *Light*—under 25% of the roots galled; *Nil*—not infested.

4, 2, 1, 0 VALUES

By giving the values 4, 2, 1 and 0 to heavy, medium, light and no infestation respectively, and expressing the sum in percentage of the total possible infestation on this basis, which is 4 X number of plants, the degree of infestation of any plot can be expressed conveniently in a single figure. These values are given in the tables included in this report.

LIMITATIONS IN THE MEASUREMENT OF SOIL INFESTATION BY MEANS OF INDICATOR CROPS

It is necessary to stress the fact that in using indicator crops, such as tobacco, to ascertain soil infestation, the measurement is based, not directly on the number of nematodes in the soil, but on the lesions produced on the plant roots. This method of measurement has definite limitations, the most important of which is the fact that there is a limit to the amount of lesions which can be produced, or at least satisfactorily measured. It follows, therefore, that, while indicator crops afford a more or less satisfactory measurement of the nematode population in the soil up to a certain degree of density, they do not furnish a measurement above that density. Soil infested above the measurable density may be said to be *hyper-infested*, and it is apparent that this degree of infestation is quite readily attainable.

It is obvious that if the soil is sufficiently hyper-infested, a large proportional reduction of nematode may still leave the soil heavily infested by indicator crop measurement, and a treatment bringing about such a reduction may appear to have failed to effect anything at all. On the other hand, if the same treatment is applied to soil which is heavily infested and nothing more, a very satisfactory reduction may be recorded.

Another point is that, owing to the fact that the nematode population is not uniformly distributed in the soil, a piece of land containing a nematode population which, on the average, is well above the measurable limit, will not necessarily return 100% heavy infestation in an indicator crop. It would seem, in fact, that infestation figures between, say 90% and 100% in an indicator crop, may refer to quite a wide range upwards of average nematode density in the soil.

It is necessary, among other points, to realize that a reliable comparison, based on infestation figures, cannot be made between results following (1) a nematode-reducing treatment, such as a resistant crop, and (2) a nematode-increasing treatment, such as a susceptible crop. The fact that the first gives a figure of 66% and the second a figure

of 99% does not show that the nematode density following the one is two-thirds of that following the other. The difference in all probability is very much greater; 66% is a measurable density, but 99% may refer to almost anything in an upward direction.

The stands of tobacco obtained in certain instances in these trials were unduly low. This was due mainly to the prevalence of white grubs, combined with the fact that weather conditions were unfavourable for repeated refilling.

ROTATIONS AND ADDITIONAL WINTER PLOUGHINGS—X LAND .

The objects and lay-out of these trials were detailed in last year's report.

The winter ploughing treatments were continued throughout the 1944 dry season.

The trials involving two seasons under resistant and susceptible crops respectively matured during the past season. Twelve sub-plots were included in each treatment in a randomized block lay-out.

The resistant rotation consisted of: *Sunnhemp* (turned under in early May)—*maize*—tobacco. The growth of the maize was very uneven in respect to the different sub-plots, varying from excellent to very poor. The whole crop was reaped and nothing returned to the soil.

The susceptible rotation consisted of: *Kaffir beans* (turned under in early May)—*sunflowers*—tobacco. The growth of the sunflowers was also very uneven between sub-plots, with a similar range to that of the maize. The whole crop was reaped and nothing returned to the soil.

The mean infestation of the twelve *sunflower* plots was 67.4% at 4, 2, 1, 0 values. Actually 99.1% of the plants showed galling in a greater or lesser degree.

The very low infestation recorded in the tobacco following one season under sunnhemp, as recorded in the previous season, led to a second crop of tobacco being planted on the sub-plots concerned. This rotation was, therefore, *sunnhemp* (turned under in early May)—*tobacco*—tobacco.

Field Notes on Growth of Test Tobacco

The growth and colour of the test tobacco was recorded on 13th February. There was little difference between the rotations (1) sunnhemp—maize—tobacco and (2) sunnhemp—tobacco—tobacco, the colour being, in general, still green with the leaves ripening slowly, while the growth was generally good. In the first rotation there were, however, no plants completely stunted by nematode attack, but sixteen such plants were counted in the second rotation.

In the susceptible rotation, the growth varied from poor to fair, and the colour was yellow almost throughout. Forty-eight completely stunted plants were counted in these sub-plots, and the growth was generally uneven.

TABLE I

Showing the infestation and yield of tobacco following different winter ploughing treatments

No. and Months of Ploughings	Means—All Plots			
	Infestation, 4, 2, 1, 0 vals.	% of Mean	Yield lbs. p.a.	% of Mean
1—May	57.0	102.5	815	99.8
3—May, June, July	53.6	96.4	787	96.3
3—May, September, October	56.1	100.9	849	103.9

Including all three rotations

The differences in both infestation and yield are non-significant.

There was, therefore, no significant benefit from the additional winter ploughings.

TABLE II

Showing the infestation, yield, price and value of tobacco following different rotation treatments on infested soil—X land

Treatment	Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
(1) SH—M—Tob	18.9	81.5	915	6.28	£24 0 0
(2) SH—Tob—Tob	56.4	87.0	854	6.54	£23 8 0
(3) KB—Sf—Tob	91.3	85.7	693	6.09	£17 12 0

SH—Sunnhemp; KB—Kaffir beans; Tob—Tobacco; M—Maize;
Sf—Sunflowers

Standard Error

Infestation, 5.81%; Yield, 3.72%; Price, 2.00%; Value, 7.43%.

Infestation

The differences are highly significant by "F." A difference of 14.3% is significant at the 1% point.

Therefore—

- (1) is better than (2);
- (1) is better than (3);
- (2) is better than (3);

all significant at the 1% point.

The infestation results are shown graphically in the adjoining diagram:—

1. Sunnhemp — maize — tobacco.
2. Sunnhemp — tobacco — tobacco.
3. Kaffir Beans — sunflowers — tobacco.

The line on the left side of each column shows the corresponding 4, 2, 1, 0 value.

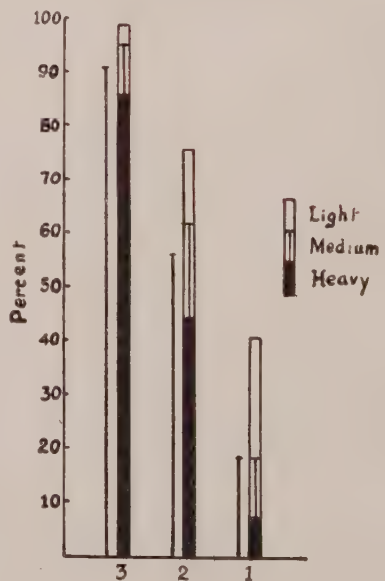


Figure 1

Figure 1 shows diagrammatically the mean percentage infestation of tobacco, following different two-season rotations on moderately infested soil (refer (Table II).

The infestation recorded in the 1943-44 season in the case of tobacco following one season under sunnhemp (turned under late) was 14.5% (SE 1.77), and following kaffir beans (turned under late) it was 84.2% (SE 2.44). The slightly greater infestation recorded during the past season where maize had intervened between sunnhemp and tobacco is not significant. The increase where sunflowers had intervened between kaffir beans and tobacco is significant by "t" at the 5% point. The rise in infestation where tobacco had intervened between sunnhemp and tobacco, namely from 14.5% to 56.4% (SE 4.13) is highly significant.

Yields

The differences are highly significant by "F."

A difference of 90-lbs. is significant at the 5% point.

A difference of 122-lbs. is significant at the 1% point.

Therefore—

(1) and (2) are both better than (3), significant at the 1% point.

The difference between (1) and (2) is not significant.

Price

The differences are not quite significant by "F" at the 5% point, but are very nearly so (3.24 against a required 3.44). If "t" be applied, (2) is just significantly better than (3) at the 5% point.

Value

The differences are highly significant by "F."

A difference of £5 3s. is significant at the 5% point.

Therefore—

(1) and (2) are both better than (3) at the 5% point.

Discussion

In this trial the correlation between infestation and yield is only apparent where the former is very high, i.e., following the susceptible rotation (3). The result in rotation (2) furnishes a contribution to the evidence, which appears to be accumulating to the effect that moderate infestation with nematode does not have much effect in reducing yield. The yields from rotations (1) and (2) may be regarded as satisfactory as far as weight of leaf is concerned, seeing that the X land is relatively low in fertility. The quality of the tobacco from both rotations, as reflected in the price, was not, however, very good, and the reason for this is not apparent.

The indications from this trial to date are as follows:—

(1) While *maize* as a rotation crop may not have much effect in reducing the nematode population in the soil, the variety used, namely "Hickory King," did not bring about any marked increase in one season. It may, therefore, prove useful in rotation with resistant legumes, such as sunnhemp, which have a nematode-reducing effect. The effect of maize on the yield and, especially, the quality of tobacco under Southern Rhodesian conditions calls for further investigation. In the United States of America it is reported to have an excellent effect on leaf quality when grown immediately previous to tobacco.

(2) The increase in nematode brought about by one crop of tobacco, following sunnhemp, was insufficient to cause a radical reduction in the yield of a second crop. In this connection it is to be noted that the infestation following sunnhemp in this instance was very low indeed, only 3.5% of the plants showing heavy infestation (see last year's report).

(3) Heavy soil infestation with nematode, such as is likely to be built up by the growing of susceptible crops for two years in succession, may cause serious reduction of yield and, possibly, have a depressing effect on quality. It is not possible, however, altogether to disassociate in this instance the effect of heavy infestation from the direct effect of the sunflower crop, in either respect.

The lack of beneficial effect in respect to infestation following the winter ploughings treatments is in harmony with (1) tests detailed in last year's report, indicating that additional winter ploughings do not bring about a more thorough drying out of the soil, taking the top six inches as a whole, and (2) tests during the past year indicating that in the dry season the bulk of the nematode population is concentrated below the six-inch level (see Table XIX).

DHAL v. WEED FALLOW

EXPERIMENT 1

The results of the trial on the X land with one year under *dhal*, compared with a similar period under *weed fallow*, were given in last year's report. No significant difference was recorded between the results of the two treatments. A trial in the same series, covering two years, matured during the past season. The randomized lay-out provided four replications of each treatment.

The dhal plants and weeds were removed, and the plots dug over on 9th November, 1944.

The roots of 281 of these two-year-old dhal plants were examined, and 21 were found to be more or less conspicuously galled. Microscopic examination revealed the presence of numerous female nematodes and egg masses in the galled plants.

TABLE III

Showing the infestation, yield, price and value of tobacco following two years under (1) *dhal* and (2) *weed fallow*. Exp. 1, X land

Treatment				Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
Dhal	..	..	..	68.5	72.1	564	6.60	£15 8 0
(SE)	..	..	..	(1.70)		(53.7)		(1.07)
Weeds	..	..	..	36.5	71.5	694	6.57	£19 0 0
(SE)	..	..	..	(4.14)		(11.8)		(0.61)

Infestation

The difference is significant by "t" at the 1% point.

Yield

The difference is not quite significant at the 5% point, but is very close to it, a difference of 134-lbs. being required.

Price

There is obviously no significant difference.

Value

The difference is significant at the 5% point, £3 0s. 0d. being required.

EXPERIMENT 2

An exactly similar series of trials were laid down on the more heavily infested Z land in 1943. For the one-year test the dhal and weeds were removed and the plots dug over on 9th November, 1944. The roots of the dhal showed a small degree of infestation with nematode.

TABLE IV

Showing the infestation, yield, price and value of tobacco following one year under (1) *dhal* and (2) *weed fallow*. Exp. 2, Z land

Treatment	Infest. % 4, 2, 1, 0 vals. ~	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
Dhal	77.5	80.2	753	7.10	£22 6 0
(SE)	(3.89)		(22.2)		
Weeds	91.9	78.3	668	7.13	£19 16 0
(SE)	(2.47)		(38.2)		

Infestation

The difference is significant by "t" at the 5% point.

Yield, Price, Value

The differences are non-significant.

Discussion

The results of these two trials, in respect to effect on the nematode, appear at first sight to be mutually contradictory. There are two possible explanations, both of which may be contributory to the difference in result.

The first of these is the variability in the composition of "weed fallow." The weeds in the one-year trial (Exp. 2), in fact, included a considerably higher proportion of species that are known to be favoured hosts of the nematode, compared with those in the two-year trial (Exp. 1). due, presumably, to the difference in the nature of the soil between the X land and the higher part of the Z land. Such species as *Hibiscus cannabinus*, *Cassia mimosoides*, *Vigna vexillata*, *Sphenostylis erecta*, *Amarantus thunbergii*, *Cleome monophylla* and *Tephrosia spp.* were more or less well represented in the case of Exp. 2, whereas they were absent or very poorly represented in the case of Exp. 1.

There is, however, a distinct possibility that the strain of dhal used in these experiments becomes less resistant with age. This, in fact, appears to be the only deduction that is in full harmony with the data so far obtained. It is to be recalled that attempts to infest the seedlings in pots were almost completely unsuccessful, while considerable infestation was noted in the case of plants that had grown for a year or more in infested soil in the field. Further experiments would be necessary

to confirm this theory or otherwise. Results to date, however, suggest that this strain of dhal may reduce infestation of the soil during the first season of growth, but increase it during the second season. In the case of Exp. 1, the rise from an infestation of 33.5% (SE 8.15) after one season to an infestation of 68.5% (SE 1.70) after two years under this crop, is very significant (see last year's Report).

It would appear that during the first season dhal may be better than some compositions of weed fallow, but no better than others in respect to controlling nematode.

In general, the planting of local strains of dhal to grow for several seasons between tobacco crops on infested soil cannot be recommended as the result of the experiments so far completed.

ONE-SEASON TREATMENTS OF HEAVILY INFESTED SOIL—Z LAND

The primary object of this trial was to test the effect of certain drastic treatments which might be applicable to reclamation of excessively infested land, but could not be applied as routine farm practice, with the object of preventing increase of the nematode.

The drastic treatments in reference were:—

- (1) Monthly ploughings of the soil during the dry season ;
- (2) Bare fallow extending from the end of one wet season to the beginning of the second wet season following, thus including two dry seasons and one wet season, a period of some 19 months.

Tests with certain resistant crops, weed fallow and one susceptible crop were also included in the trial, the two last-named as controls to the effect of the other treatments.

The piece of land was divided into four blocks, each of which was divided into four main plots, and these were divided into nine sub-plots in each case, making a total of 144 sub-plots.

The blocks provided for four different winter treatments of the soil, namely (1) one ploughing only—in May; (2) three ploughings—in May, September and October respectively; (3) four ploughings—in May, July, September and October respectively; (4) six ploughings—one in each month from May to October inclusive. There were thus four replications of each winter treatment. These were randomized within the blocks.

The main plots provided for nine different summer treatments, namely: (1) bare fallow; (2) weed fallow; (3) kaffir beans; (4) sunn-hemp; (5) velvet beans; (6) maize; (7) munga; (8) teff grass; (9) groundnuts, giving sixteen replications of each summer treatment. These treatments were randomized within the main plots.

The summer treatment trials were thus superimposed upon the winter treatment trials.

The winter ploughing treatments were carried out during the dry seasons of both 1943 and 1944. The following table shows the results of the trial as far as these treatments are concerned.

TABLE V

Showing the infestation and yield of tobacco following two years of different winter ploughing treatments

No. and Months of Ploughings	Means—All Sub-Plots			
	Infestation, 4, 2, 1, 0 vals.	% of Mean	Yield lbs. p.a.	% of Mean
1—May	56.3	95.3	992	102.7
3—May, September, October ..	61.4	104.0	835	93.0
4—May, July, September, October	61.6	104.2	911	101.4
6—May, June, July, August, September, October ..	57.4	97.1	925	103.0

There is no significant difference between either the infestations or the yields following the different treatments, and no indication whatsoever of benefit from the additional winter ploughings.

(1) *Bare Fallow*.—At the beginning of the rains there was a dense germination of rapoko grass (*Eleusine indica*). This was cleaned up promptly by short interval hoeing, and throughout the growing season the soil was cleaned at intervals not exceeding three weeks. There was relatively little weed growth after the first intensive cleanings. There was extremely little weed growth during the dry season, and none later than July. Many of the sub-plots, however, produced root-suckers of *mnondo* and other forest trees, betraying the presence of living roots of these species in the soil.

(2) *Weed Fallow*.—The dominant weed in this treatment was rapoko grass. Natal Redtop (*Rhyncalytrum roseum*) and Mexican Maigold (*Tagetes minuta*) were generally prevalent. Good nematode hosts occurred in relatively small numbers. A full list of the weeds recorded is given in the Appendix. The weeds were turned under in mid-April.

(3) *Kaffir Beans* (Cowpeas).—This was the only susceptible crop included in the trial. The seed was planted on 4th December, spaced 36-ins. by 18-ins., with two seeds to each hole. Germination was good, but many plants died from nematode attack, and the misses were filled in at the end of December. The final stand and growth of the plants were poor on fully half of the sub-plots, and were only good on four out of the sixteen. On 23rd February a large number of dead and stunted plants were dug up and all were found to be very heavily galled. The crop was turned under on 4th March, and on all the sub-plots a high proportion of the plants was observed to be very heavily galled.

(4) *Sunnhemp*.—Sown during the first week of December at the rate of 50-lbs. per acre, this crop made an excellent and even growth in all cases. Weed growth was mostly smothered, but on some of the sub-plots some large plants of rapoko grass were found when the crop was turned under on 1st March.

(5) *Velvet Beans* (Marbillee).—The beans were spaced 36-ins. by 18-ins., with two to a hole, but two plantings, on 26th November and 12th December respectively, were necessary to produce a good stand.

Growth was good, with little difference between sub-plots. Turned under during the second week in March.

(6) *Maize* (Hickory King).—Planted on 10th November and kept clean throughout the growing season. Growth uneven, and on the whole very poor. Cleaned up during the second week in April, and nothing returned to the soil.

(7) *Munga* (Pearl Millet).—Broadcast on 11th December at the rate of 20-lbs. per acre. Growth uneven and mostly poor, with a considerable intrusion of weeds. Cleaned up during the second week in April and nothing returned to the soil.

(8) *Teff Grass*.—The land was cleaned three times very thoroughly before the seed was sown at the end of December, at the rate of $12\frac{1}{2}$ -lbs. per acre. A practically pure stand was secured, but the sedge, *Cyperus amabilis*, which is a host of the nematode, appeared among the grass late in the season. The growth was moderate only, but not markedly uneven between sub-plots. Cut for hay in the middle of March and stubble turned under on 18th March.

(9) *Groundnuts* (Virginia Bunch).—A planting at the beginning of December resulted in an excellent stand, and the growth was fairly good, the crop being estimated at around $12\frac{1}{2}$ bags of unshelled nuts per acre. The land was kept clean. Harvested during the second week in April, nothing being returned to the soil.

It is to be pointed out that these tests were not concerned primarily with good rotation practice in the production of flue-cured tobacco. The object in view was to obtain a measurement of the effect of individual treatments, including various resistant crops, on the nematode population. The information thus obtained could be utilized in a further study of the most suitable rotations for the production of high quality leaf on different types of soils.

Field Notes on Growth of Test Tobacco

The land included in the 144 sub-plots comprising this trial varies greatly in fertility from one end to the other. In the upper half or more the fertility appears to be above the average of that of sandveld soils, while in the lower portion the soil is lighter in colour, more sandy and poorer. The result during the past season was that, with the same applications of fertilizer, the growth, covering all treatments, was markedly heavier in the upper portion where, also, ripening was delayed. Many of the sub-plots, especially those into which a legume had been turned the previous season, showed growth which gave the impression of being too heavy for the production of the best quality flue-cured leaf, and this refers to kaffir beans as well as resistant legumes.

The sub-plots on which the tobacco followed kaffir beans were, however, distinguishable in nearly all cases by the presence of completely unproductive, stunted plants with drooping leaves, betraying the heavy infestation of the soil.

Apart from a few exceptionally fertile sub-plots, the crops following *maize* and *munga* made fair growth only and ripened early. The tobacco in these two treatments appeared to be very similar. Completely stunted plants were, however, rare.

The growth following weed fallow and groundnuts was, in general, fairly good to good, and there was no undue delay in ripening.

Among the worst sub-plots in the series appeared to be those on which tobacco followed *teff* grass. With a few exceptions, the growth was poor and uneven, and the plants yellowed early. Completely stunted plants were present in appreciable numbers.

Following *bare fallow* the tobacco, in nearly all cases, made surprisingly good growth which tended to be decidedly heavy. The tobacco ripened better than in the legume treatments but, on the whole, later than the non-legume treatments. Completely stunted plants were conspicuously absent, and the growth was notably uniform.

The following list shows the number of tobacco plants in each of the nine treatments in this trial which were completely stunted through nematode attack and produced no marketable leaf :—

f. Bare Fallow	0	f. Teff Grass	27
f. Sunnhemp	1	f. Kaffir Beans	173
f. Munga	2	f. Maize	7
f. Weed Fallow	13	f. Groundnuts	2
f. Velvet Beans	0		

TABLE VI

Showing the infestation, yield, price and value of tobacco following different one-season summer treatments on heavily infested soil. Z land

Treatment	Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
Bare Fallow	36.2	90.8	1,078	7.20	£32 7 0
Weed Fallow	70.8	85.8	945	6.86	£27 0 0
Kaffir Beans	92.1	82.5	791	6.29	£20 16 0
Sunn hemp	58.1	86.7	1,007	6.67	£27 18 0
Velvet Beans	52.8	88.3	1,002	6.93	£28 18 0
Maize	64.7	85.0	820	7.01	£24 0 0
Munga	53.9	79.2	813	6.84	£23 1 0
Teff Grass	68.7	82.5	819	6.75	£23 1 0
Groundnuts	35.2	85.0	881	6.78	£25 0 0

Standard Error

Infestation 3.81% ; Yield 4.17% ; Price 1.78% ; Value 4.73%.

Infestation

The differences are highly significant by "F."

A difference of 7.5% is significant at the 5% point.

A difference of 10.8% is significant at the 1% point.

Therefore—

Bare Fallow and *Groundnuts* are both better than any of the other treatments; highly significant.

*Velvet Beans** and *Munga* are better than *Maize*, *Teff*, *Weed Fallow* and *Kaffir Beans*; significant at the 1% point.

Sunn hemp is better than *Weed Fallow* and *Kaffir Beans*, significant at the 1% point; better than *Teff*, significant at the 5% point.

Maize, *Teff* and *Weed Fallow* are better than *Kaffir Beans*, significant at the 1% point.

The infestation results are shown graphically in the following diagram:—

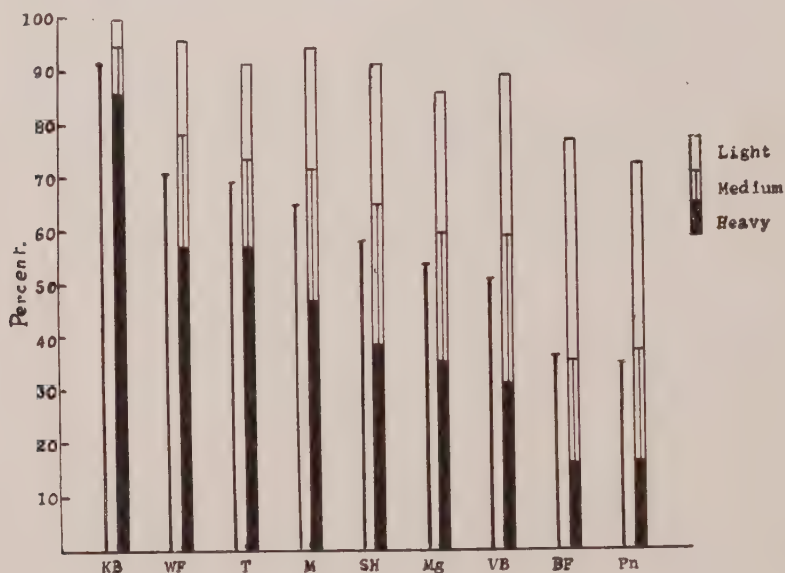


Figure 2

KB—Kaffir Beans; WF—Weed Fallow; T—Teff; M—Maize;
SH—Sunnhemp; Mg—Munga; VB—Velvet Beans; BF—Bare
Fallow; Pn—Groundnuts

The line on the left side of each column shows the corresponding 4, 2, 1, 0 value.

Figure 2, showing diagrammatically the mean percentage infestation of tobacco following different one-season treatments on heavily infested soil (refer Table VI).

Yield

The differences are highly significant by "F."

A difference of 108-lbs. is significant at the 5% point.

A difference of 141-lbs. is significant at the 1% point.

Therefore—

Bare Fallow is better than *Groundnuts*, *Maize*, *Teff*, *Munga* and *Kaffir Beans*, significant at the 1% point; and better than *Weed Fallow*, significant at the 5% point.

Sunnhemp and *Velvet Beans* are both better than *Maize*, *Teff*, *Munga* and *Kaffir Beans*, significant at the 1% point; and better than *Groundnuts*, significant at the 5% point.

Weed Fallow is better than *Kaffir Beans*, significant at the 1% point; and better than *Maize*, *Teff* and *Munga*, significant at the 5% point.

Price

The differences are significant by "F" at the 1% point.

A difference of 0.33 is significant at the 5% point.

A difference of 0.43 is significant at the 1% point.

Therefore—

Bare Fallow is better than *Sunnhemp*, *Teff*, *Groundnuts* and *Kaffir Beans*, significant at the 1% point; and better than *Weed Fallow* and *Munga*, significant at the 5% point.

Maize is better than *Kaffir Beans*, significant at the 1% point; and better than *Sunnhemp*, significant at the 5% point.

Velvet Beans, *Weed Fallow*, *Munga*, *Teff* and *Groundnuts* are all better than *Kaffir Beans*, significant at the 1% point.

Sunnhemp is better than *Kaffir Beans*, significant at the 5% point.

Value

The differences are highly significant by "F."

A difference of £1 2s. is significant at the 5% point.

A difference of £1 10s. is significant at the 1% point.

Therefore—

Bare Fallow is better than any of the other treatments, significant at the 1% point.

Velvet Beans are better than *Weed Fallow*, *Maize*, *Munga*, *Teff*, *Groundnuts* and *Kaffir Beans*, significant at the 1% point.

Sunnhemp and *Weed Fallow* are better than *Maize*, *Munga*, *Teff*, *Groundnuts* and *Kaffir Beans*, significant at the 1% point.

Groundnuts are better than *Munga*, *Teff* and *Kaffir Beans*, significant at the 1% point.

Maize, *Munga* and *Teff* are all better than *Kaffir Beans*, significant at the 1% point.

Discussion

The most outstanding result of this trial, as far as control of nematode is concerned, is the relatively light infestation following *groundnuts*, compared with any of the other treatments, apart from *bare fallow*. The latter is regarded as the most drastic cultural procedure that can be adopted with a view to reducing the pest. This result is in harmony with those of recent trials in the United States of America, which indicate that *bunch groundnuts* are the most reliable of nematode-reducing crops. The inferior results from *sunnhemp* and *velvet beans* are noteworthy.

In last year's Report a very low infestation, namely, 14.5%, was recorded in tobacco following one season under *sunnhemp* (turned under late) on the moderately infested X land. The much higher infestation following this crop in the present trial is, of course, explicable on the basis of the much heavier infestation of the Z land before the treatment was applied.

On the other hand, there is a factor which might explain, at least partially, a difference in the effectiveness of *sunnhemp* in reducing

nematode in the respective trials. In the case of the experiment on the X land the sunnhemp was turned into the soil on 5th May, after the dry season was well established, with the result that decomposition would be largely delayed until the next growing season. In the experiment on the Z land the crop was turned in at the end of February, and had certainly broken down before the soil dried in the ensuing dry season. There is evidence from elsewhere that the presence of decomposing organic matter in the soil is inimical to the nematode, and it is conceivable, therefore, that the first-mentioned method of handling the crop may be the more effective in respect to nematode control. Experiments are in progress to furnish data in this connection.

With regard to the remaining resistant crops, it would appear that they all had the effect of reducing nematode in some degree, if the comparison with *sunnhemp*, which has a well-established reputation in respect of nematode reduction, is a reliable indication. It is of particular interest that the infestation following *maize* (Hickory King) was not significantly greater than that following sunnhemp, because maize is not now regarded as a nematode-reducing crop in the United States of America. Possibly the white dent varieties, generally grown in this Colony, may be more resistant than the yellow maize favoured in America.

In general, it appears that something more than one season's treatment of heavily infested soil is necessary to reduce nematode to more or less negligible density.

In respect to *yield*, *quality* and *return per acre*, the most unexpected result was the effect of *bare fallow*, which was better than any of the other treatments in all three particulars. Referring again to reports from the United States of America we find the following statement: "Tobacco grown after bare fallow was very free from root knot, but the yield usually was lower than that of more severely diseased tobacco following corn or even tobacco." . . . "Bare fallow has reduced tobacco yield just as much as severe root knot, so that this treatment has not been a profitable one. Moreover, flue-cured tobacco *quality* was often lowered by bare fallow rotations, with the result that the dollar returns per acre were still further reduced."

There is no question that the bare fallow treatment did not have this effect, in comparison with other treatments, on the Thurbar land. Not only was its superiority apparent over the sixteen replications in this particular trial, but was patent also over a further eighteen plots in another trial, with trap crops, to be described later.

The explanation is, possibly, that the piece of land concerned is rather high in fertility for the production of the best quality flue-cured leaf, and that the leaching of the bare fallow plots had the effect of making the soil more suitable for this purpose. It is to be remarked, however, that even in the least fertile block (A)—see page 67—bare fallow was still at the top in price and value, although it was slightly exceeded by sunnhemp in weight of yield. It would seem that the effect of bare fallow is deserving of further study on different types of soil in this Colony.

The lowest yield, price and value were obtained from the very heavily infested plots on which tobacco followed *kaffir beans*. It is difficult to deduce otherwise than that the depression of all three was

directly due to the heavy infestation. The kaffir bean crop had been turned under about the same time as the sunnhemp and velvet beans, and the effect on the soil and the quality of the subsequent tobacco crop, excluding nematode, would presumably not differ greatly from that of the other legumes, similarly treated. The quantity of organic matter supplied to the soil by the kaffir bean crop was, in fact, materially less than in the case of either sunnhemp or velvet beans, due to the relatively poor growth of the heavily infested kaffir bean plants. If we consider also the relatively poor quality following sunflowers in the susceptible rotation on the X land, it appears to be probable that nematode infestation, possibly above a certain degree, has of itself a directly depressing effect on tobacco leaf quality.

Groundnuts, although greatly reducing nematode in the soil, did not show up so well in respect to the yield and quality of the tobacco that followed, and the value of the crop reaped was only significantly better than that following kaffir beans. Further tests are needed, but, in any event, a crop which has an outstanding nematode-reducing effect, and is also a cash crop suitable for the sandveld, seems likely to prove very useful in rotations on nematode-infested soils.

SPECIAL COTTON TRIAL—Z LAND

The strain of cotton, 9L34, from the Cotton Breeding Station, Gatooma, which had shown very high resistance to nematode attack in pot tests (see previous Annual Reports) was given a special trial as a rotation crop with tobacco on nematode-infested soil.

Sixteen plots of "Z" land were used, and four treatments were included, namely, *cotton*, *sunnhemp*, *weeds* and *kaffir beans*. The lay-out was a Latin Square, with four replications of each treatment.

The following notes refer to the treatments:—

(1) *Cotton*.—The seed was sown on 25th November, several seeds to a hole. A very good stand resulted, but the plants made exceedingly poor growth, the average height being little over 12-ins. The yield was negligible. The plants, 1,230 in all, were lifted on 17th May, and the roots examined individually, with the result that no galls were found.

(2) *Sunnhemp*.—Sown at the rate of 50-lbs. per acre on 3rd December; a good crop was turned under on 1st March.

(3) *Kaffir Beans*.—These were planted on 6th December and the germination was good. Final stands and growth were, however, only fair. The crop was turned in on 15th March, when the infestation of the roots was noted to be generally heavy.

(4) *Weed Fallow*.—The dominant weeds in these plots were the same as those already mentioned in connection with the one season treatment trials on the Z land, but first-class hosts of the nematode were more abundant. One plot was thickly stocked with *Indigofera hirsuta*, a susceptible host, and another with *Hibiscus cannabinus*, which is still more readily attacked.

Field Notes on Growth of Test Tobacco

The growth on the plots where the tobacco followed *sunnhemp* and *weed fallow* was heavy and ripening was delayed. Following *kaffir beans* the growth was uneven, with many heavy plants. Good, but not heavy growth was made following *cotton*, and these plots ripened earlier than the others. Seventy-nine completely stunted plants were counted following *kaffir beans*, three following *weed fallow*, and none at all following *cotton* and *sunnhemp*.

TABLE VII

Showing the infestation, yield, price and value of tobacco following cotton (9L34) and other treatments on very heavily infested soil. Z land.

Treatment				Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre		
Cotton	..	..	..	45.1	77.8	992	7.53	£31	1	0
Sunnhemp	..	..	..	87.2	71.9	860	6.95	£25	1	0
Kaffir Beans	..	..	..	99.0	66.3	509	6.32	£13	8	0
Weeds	..	..	..	91.6	67.5	908	7.17	£27	4	0

Standard Error

Infestation 2.36% ; Yield 3.83% ; Price 2.89% ; Value 6.46%.

Infestation

The differences in the figures are highly significant by "F."

A difference of 6.6% is significant at the 5% point.

A difference of 10.0% is significant at the 1% point.

Therefore—

Cotton is better than any of the other treatments; highly significant.

Sunnhemp is better than *Kaffir Beans*, significant at the 1% point.

Weed Fallow is better than *Kaffir Beans*, significant at the 5% point.

The infestation results are shown graphically in the following diagram:—

KB—Kaffir Beans; WF—Weed Fallow; Sh—Sunnhemp; C—Cotton.

The line on the left side of each column shows the corresponding 4, 2, 1, 0 value.

Figure 3, showing diagrammatically the mean percentage infestation of tobacco following cotton (9L34) and other treatments on very heavily infested soil (refer Table VII).

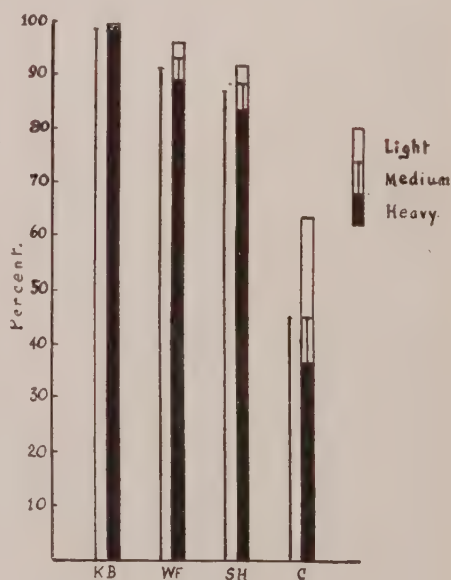


Figure 3

Yield

The differences are highly significant by "F."

A difference of 90.3-lbs. is significant at the 5% point.

A difference of 136.8-lbs. is significant at the 1% point.

Therefore—

Cotton is better than *Kaffir Beans*, significant at the 1% point,
and better than *Sunnhemp*, significant at the 5% point.

Sunnhemp and *Weed Fallow* are both better than *Kaffir Beans*,
significant at the 1% point.

Price

The differences are significant by "F" at the 5% point.

A difference of 0.70d. is significant at the 5% point.

A difference of 1.06d. is significant at the 1% point.

Therefore—

Cotton is better than *Kaffir Beans*, significant at the 1% point.

Weed Fallow is better than *Kaffir Beans*, significant at the 5%
point.

Value

The differences are highly significant by "F."

A difference of £4 6s. is significant at the 5% point.

A difference of £6 10s. is significant at the 1% point.

Therefore—

Cotton is better than *Sunnhemp*, significant at the 5% point,
and better than *Kaffir Beans*, significant at the 1% point.

Sunnhemp and *Weed Fallow* are both better than *Kaffir Beans*,
significant at the 1% point.

Discussion

There is no question that the cotton crop had a very marked effect in reducing the nematode population in the soil.

It may appear at first sight that the effect of the cotton was inferior to that of *groundnuts* or *bare fallow* in the previous trial, namely an infestation of 56.1% against 35.2% or 36.2%. Closer examination of the results of the two trials does not, however, support this view. The initial nematode density in the piece of land used for the cotton trial was undoubtedly greater even than that of the land used for the previous trial, as is shown by the respective infestations following *sunnhemp*, *weed fallow*, and *kaffir beans*. Expressed in percentage of that following *sunnhemp* in the same trial the infestation following *groundnuts* gives the figure of 60.5%, while on the same basis the infestation following *cotton* gives the lower figure of 51.7%. Expressed in percentage of the respective infestations following *weed fallow* in the same trials the figure for *cotton* is 49.2% and that for *groundnuts* is 49.7%, almost exactly the same.

As far as these experiments are concerned cotton (9L34) must be regarded as having had an effect equal to that of *groundnuts* and *bare fallow* in reducing nematode, while the effect of *sunnhemp*, turned under early, was again markedly inferior.

In the United States of America cotton is not regarded as having marked nematode-reducing qualities, and it would seem that the strain used in this trial is more resistant than the strains usually cultivated in that country.

Contrary to the results following groundnuts, the tobacco following cotton gave a heavy yield, in view of the relatively poor stand, and the mean price was higher than that in any of the other trials. In the United States of America cotton is reported as inducing excellent leaf quality in tobacco planted the following season.

The one unsatisfactory feature of this trial is the failure of the cotton to produce a crop on the type of soil and in the season concerned. The excessively wet season had, no doubt, something to do with this failure, if it did not fully account for it. Profitable cotton crops can be grown on sandveld soil, and suitable treatments of particular types can, presumably, be evolved.

EFFECT OF COMPOST

The two pieces of land, in the X and Z sections respectively, which were used in previous seasons for testing out the effect of compost applications, were used again for the same purpose during the past season, the object being to test for cumulative effect on the nematode. The same four levels of compost were applied, namely 0, 4, 8 and 16 tons, each plot receiving the same quantity as in previous seasons. The lay-outs provide four replications of each treatment.

EXPERIMENT 1 (X LAND)

In this trial the compost was broadcast over the soil and was lightly hoed in on 18th November. On 20th November standard fertilizer was applied round the markers, at the rate of 100-lbs. per acre, and the soil was then hoed up into hills. An additional application of fertilizer at the rate of 200-lbs. per acre was given on 21st December, as elsewhere.

Field Notes on Growth of Test Tobacco

The growth on the plots which received the heavier dressings of compost was markedly heavier than on those which received none, and the crop on the latter ripened considerably earlier. Nematode damage in the form of completely stunted unproductive plants was also significantly greater on the non-composted plots. Thirty-two such plants were counted on the non-composted plots, as against seven, eight and seven on those which received four, eight and sixteen tons respectively.

TABLE VIII

Showing the infestation, yield, price and value of tobacco following applications of the same respective levels of compost for the third season in succession. Exp. 1, X land

Compost Tons p.a.	Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
0	81.4	86.0	625	5.73	£15 8 0
			(SE 122.7)		
4	86.1	91.5	843	6.60	£23 3 0
8	83.8	85.4	780	6.48	£21 0 0
16	80.5	83.3	962	6.53	£26 6 0
			(SE 70.0)		

Standard Error

Yield 10.25% ; Price 3.90% ; Value 12.16%.

The differences in infestation, yield, price and value are all non-significant.

It may be remarked that the lack of significance in the differences between the yields, and consequently between the values, is mainly due to the enormous variation in the yields from the non-composted plots, as revealed by the standard error. Even so, the difference between the yield from 16 tons and that from no compost is almost significant by "t." In reality, there can be little doubt that the compost applications materially increased the yield.

TABLE IX

Showing the infestation of tobacco season by season following applications of the same quantity of compost respectively to the same plots

Compost Tons p.a.	Infestation %: 4, 2, 1, 0 Values		
	1942-43	1943-44	1944-45
0	29.4	44.3	81.4
(SE)	(4.19)	(4.90)	(2.23)
4	45.3	48.5	86.1
(SE)	(4.89)	(4.86)	(4.20)
8	50.0	54.3	83.8
(SE)	(5.56)	(5.75)	(4.28)
16	40.9	47.0	80.5
(SE)	(3.75)	(3.43)	(4.18)

The infestation following all the treatments is highly significantly greater in the 1944-45 season than in the preceding seasons.

EXPERIMENT 2 (Z LAND)

Repeating the procedure followed on the same piece of land last season, the compost was applied round the markers with suitable measures. It was then mixed with the soil, forming small mounds. Standard fertilizer was applied on the tops of these mounds at the rate of 100-lbs. per acre, and the hills were completed by drawing soil up to cover the fertilizer.

The compost was applied and hoed in on 18th November, the fertilizer being added and the hills completed on 20th November. An additional application of fertilizer at the rate of 200-lbs. per acre was given on 21st December, as elsewhere.

Field Notes on Growth of Test Tobacco

Unfortunately, very poor stands were obtained in this trial, owing to excessive prevalence of *white grubs*. The growth on all the plots was, however, heavy and ripening was delayed. Notwithstanding the obvious fertility of the soil, there were some complete failures from nematode attack. Thirty-six completely stunted plants were counted on the non-composted plots, as against eight, seven and six on those that received four, eight and sixteen tons respectively.

TABLE X

Showing the infestation, yield and price of tobacco following applications of the same respective levels of compost for the second season in succession. Exp. 2, Z land

Compost Tons p.a.	Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence
0	92.9	75.9	727	7.05
4	87.1	62.8	713	7.14
8	89.3	59.0	710	7.13
16	89.4	49.3	622	6.82

The differences in infestation and price are obviously non-significant, while the yields, and consequently the values, are of little or no importance owing to the extreme variation in the stands. Actually, in proportion to the respective stands, the yield from the non-composted plots is appreciably lower than that of the composted plots.

TABLE XI

Showing the infestation of tobacco season by season following applications of the same quantity of compost respectively to the same plots

Compost:				Infestation %: 4, 2, 1, 0 Values	
Tons per acre				1943-44	1944-45
0	..	..	..	52.3	92.9
	(SE)	..	..	(3.65)	(3.40)
4	..	..	..	55.0	87.1
	(SE)	..	..	(1.15)	(4.58)
8	..	..	..	51.8	89.3
	(SE)	..	..	(8.12)	(4.67)
16	..	..	..	48.3	89.4
	(SE)	..	..	(6.92)	(4.00)

The infestation following all the treatments is highly significantly greater in the 1944-45 season than in the preceding season.

Discussion

Experiments with applications of compost, which have now extended over three seasons, have revealed no effect whatsoever on the nematode population in the soil, even when the compost was applied in uneconomic quantities, that is, as far as tobacco culture is concerned. There is considerable evidence from other countries that really heavy additions of organic matter to the soil tend to reduce the nematode population, but such records do not necessarily apply to tobacco culture and field conditions in this Colony.

There has been no indication that applications of compost either raise or depress the quality of the leaf, but the indications are, in general, that the heavier applications tend to raise the yield, and consequently the value of the crop, appreciably, although the fact has not been conclusively demonstrated. In this connection it has been unfortunate that the piece of land used for the trial on the X land is so variable in fertility, and that white grubs were so prevalent during the past season

in the land used for the trial on the Z land. It is very probable that in the latter case the heavy attack was directly due to the compost, or to the method of applying it. The loss of plants was significantly greater on the composted plots compared with those which received none.

TRAP CROPS

Trap cropping has a poor reputation as a control measure against the root knot nematode, but unexpected promising results have been reported by a worker on the Research Station from a field trial (Annual Report, 1937). A further trial of this nature has, therefore, been carried out using sunflowers as the trap.

A varying number of trap crops in a single season were tested against bare summer fallow, the randomized lay-out providing four replications of each trapping treatment and eight replications of the bare fallow treatment. The sunflowers were broadcast thickly, the first sowing being on 11th November. The traps were lifted carefully twenty-seven days after sowing, which allowed six days for germination and twenty-one days for growth. Each successive crop was sown within a few days of the previous one having been lifted. Apart from the time when the trap crops were present, all the plots were kept in bare fallow. The trapping was carried out during the 1943-44 season, and the test tobacco was planted during the past season.

Field Notes on Growth of Test Tobacco

The growth of the tobacco in this trial was remarkably good, and, on the whole, uniform, although there were a few rankly-growing plants here and there. Only one completely stunted plant was found in the whole of the twenty-four plots. There was no suggestion of any difference between the treated and untreated plots.

TABLE XII

Showing the infestation, yield, price and value of tobacco following one season of a varying number of trap crops (sunflowers) as against bare summer fallow

No. of Trap Crops					Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre		
2	..	..	..	..	54.3	84.5	1,253	7.64	£38	17	0
3	..	..	..	..	55.6	86.7	1,092	7.26	£33	8	0
5	..	..	..	..	63.2	83.9	1,063	7.11	£31	10	0
1 (late)	..	..	..	..	49.2	85.6	1,164	7.27	£35	6	0
Nil (1)	..	..	..	..	46.8	80.9	1,057	7.37	£32	9	0
Nil (2)	..	..	..	..	59.2	85.0	1,041	7.85	£34	2	0

There is no significant difference between treatments in respect to either infestation, yield, price or value, and no indication of any benefit from the trap cropping.

As each trap crop was lifted one hundred plants were taken at random from each plot and the proportion of plants showing galls was recorded. While the results indicated a substantial reduction by the end of the season, they were, on the whole, inconsistent, and are, therefore, not given.

The one *late* crop mentioned in the Table was planted on 15th March, on the same date as the last of the *five* trap crops, to ascertain if any difference in infestation could be recorded at the end of the season following (1) *continuous trapping*, as opposed to (2) *bare fallow*. The infestation in the case of both treatments was very small, namely, 5.3% and 4.3% of plants showing galls in the case of (1) and (2) respectively. The difference is not significant.

Discussion

Apart from affording no evidence of benefit from the trap cropping, the above experiment is of interest in respect to the yields obtained. For practical purposes the whole of the plots may be regarded as having been under bare fallow the previous season, the only difference in the case of those used for the traps being the removal of a small amount of plant food from the soil. The quality of the leaf, as indicated by a mean price of 7.42 pence per lb., compares with that in the previous trial where bare fallow was included as a treatment. The results obtained, in fact, add additional evidence as to the beneficial effect of bare fallow, in respect to both yield and quality of tobacco following it on the type of soil concerned.

The infestation following bare fallow in the present trial was substantially greater than in the previous trial, namely, 54.7% against 36.2%. This was presumably due to a higher initial density of nematode in the soil in the present instance, but the figure obtained emphasizes the fact that even nineteen months of bare fallow cannot be relied upon to reduce nematode density to a negligible level, if the soil is sufficiently heavily infested.

HILLS v. RIDGES

This trial was a repetition of that carried out in the previous season, but a different piece of land was used, situated in the Y section. The soil was hoed up shallowly after the first wetting shower of the season, having been in weed fallow for several years. It may be remarked that the method of hilling advocated by Mr. A. D. Collins for application to nematode-infested land refers, normally, to previously ploughed soil which has not been disturbed for some considerable time in the late dry season. Ploughing temporarily breaks up the nematode-free layer on the surface, which is established by the dryness and heat of the late dry season. A suitable piece of previously ploughed land was, however, not available, and, as earlier tests had shown that, in the case of undisturbed soil, the nematode-free layer extended to a depth of four inches by October, it was decided that a shallow hoeing might safely be given after the first wetting shower to enable the hills to be drawn up.

The randomized block lay-out in this trial provided four replications of each treatment.

In the case of the *hilling* method, standard fertilizer was applied round the markers at the rate of 100-lbs. per acre on 20th November, and the hills were then made up.

In the case of the *ridging* method, the soil was lightly ridged and standard fertilizer was then applied round the markers, at the same rate as above, namely 100-lbs. per acre. Soil was then drawn up to

cover the fertilizer. This operation deepened the valleys and simulated satisfactorily the work of a ridging plough. This operation was also carried out on 20th November.

A further application of fertilizer at the rate of 200-lbs. per acre was given to all the plots on 21st December, making a total of 300-lbs.

TABLE XIII

Showing the infestation, yield, price and value of tobacco planted on (1) hills and (2) ridges

Treatment			Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
Hills	..	..	35.7	87.9	1,116	6.51	£30 6 0
(SE)	..	..	(5.98)	(1.55)	(60.0)		(2.30)
Ridges	..	..	40.6	79.5	927	6.46	£24 19 0
(SE)	..	..	(3.12)	(0.35)	(10.5)		(0.84)

Infestation

The difference is non-significant.

Stand

The difference is significant by "t" at the 1% point.

Yield

The difference is significant by "t" at the 5% point.

Price

There is obviously no significant difference.

Value

The difference falls short of significance by "t" at the 5% point, which requires a difference of £6 9s.

Discussion

The results of this trial are, in general, in favour of the hilling method, but the experiment needs repeating on previously ploughed soil that has been kept free from weeds throughout the dry season.

EARLY v. LATE PLANTING

Tests have shown that the nematode gradually makes its way towards the surface of the soil after the commencement of the rains. It was thought, therefore, that in the case of late-planted crops the attack on the roots was likely to be almost immediate, while early planted crops might be able to make some growth before being seriously attacked, and so suffer less from the pest.

The lay-out of the trial was on the normal randomized block plan, and provided four replications of each treatment. Y land.

The dates of the respective plantings were:—

- (1) *Early*—24th November; refilled 1st and 15th December.
- (2) *Late*—28th December; refilled 5th and 22nd January.

Both plantings received fertilizer at the rate of 300-lbs. per acre, namely 100-lbs. a few days after planting and 200-lbs. about three weeks later.

Field Notes on Growth of Test Tobacco

Growth was good and uniform in the case of both treatments, and there was no sign of stunting of plants, due to nematode attack. The earlier prospects promised heavy crops of good quality leaf from both dates of planting, but ripening was delayed in both cases, leading to abnormally heavy late pickings.

TABLE XIV

Showing infestation, yield, price and value of tobacco planted (1) early and (2) late

Date of Planting		Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
24th November ..	..	83.6	89.6	1,128	6.33	£29 15 0
(SE) ..	..	(4.99)	(1.54)	(23.21)	(0.14)	(0.83)
28th December ..	..	39.4	85.6	860	5.40	£19 7 0
(SE) ..	..	(5.86)	(0.93)	(24.77)	(0.28)	(1.26)

Applying "t":—

Infestation

The difference between treatments is highly significant.

Stand

The difference is non-significant, though by a small margin only.

Yield

The difference is highly significant.

Price

The difference is significant at the 5% point.

Value

The difference is highly significant.

Discussion

The result in respect to infestation is exactly the opposite of what was anticipated, the late-planted crop being much the less severely infested. No explanation of this phenomenon can be attempted until further trials have been carried out.

In all other respects the early planting gave greatly superior results, emphasizing the minor part which nematode infestation may play in determining yield, etc.

It is to be noted that, although the quality of leaf produced by the earlier planting is significantly better than that produced by the later planting, the actual quality, as indicated by a mean price of 6.33 pence, is decidedly on the poor side. The fact is that both treatments produced poor quality leaf, but that the later planting produced the poorer. This fact must be attributed to factors outside the scope of the trial.

FERTILIZER LEVELS

Statements are to be found in the literature on root knot nematode to the effect that application of increased quantities of artificial fertilizers have little effect in increasing the yield of susceptible crops on infested soil.

A trial with tobacco in this connection was carried out, using three different levels of standard fertilizer, namely, 200, 400 and 600-lbs. per acre respectively.

The piece of land used was in the Y section, i.e., newly broken from several years in weed fallow. There were four replications of each treatment in a randomized block lay-out.

The fertilizer was applied fractionally as follows:—

Level: lbs.	Applications: lbs.		
	29th Nov.	20th Dec.	12th Jan.
200	50	100	50
400	100	200	100
600	150	300	150

Field Notes on Growth of Test Tobacco

The growth generally was good to heavy, and the heavier applications of fertilizer appeared to promise considerably heavier yields. There were no stunted plants in any of the treatments. The crops, however, ripened late, as elsewhere in the Y section.

TABLE XV

Showing the infestation, yield, price and value of tobacco on nematode infested soil, given three different levels of standard fertilizer

Level lbs.					Infest. % 4, 2, 1, 0 vals.	Stand %	Yield lbs. p.a.	Price per lb. pence	Value per acre
200	60.2	90.7	980	6.51	£26 12 0				
400	65.1	85.7	1,042	6.46	£28 1 0				
600	71.6	85.0	1,101	6.36	£29 4 0				

Standard Error

Infestation 10.30% ; Yield 6.25%.
The results are non-significant by “ F ” in every respect.

Discussion

The promise of considerably heavier yields from the heavier applications was not fulfilled. It appears that the levels were based upon too high a minimum for the class of soil, and, especially the class of season which occurred. These levels were decided upon on the basis of experience the previous season, when 400-lbs. of fertilizer failed to produce even a reasonably good crop on the Thurbar land. In the present trial, the fertilizer in excess of 200-lbs. per acre was obviously in excess of requirements for a good yield under the prevailing conditions, and contrasting results are therefore lacking. A more comprehensive trial on a different class of soil is indicated.

SOME FIGURES REFERRING TO SOIL FERTILITY AND NEMATODE INJURY

The yield of tobacco from any piece of nematode-infested land, other things being equal, is the resultant of the effect of two factors, namely, (1) the fertility of the soil, and (2) the degree of infestation of the crop.

The fact that high soil fertility may, to a very large extent, counteract the effect of quite severe nematode infestation is now generally recognized, and has been conspicuous in the course of the experiments under review. Considerably higher yields have, in short, been obtained from badly infested plots, in certain cases, than from others in which the infestation was negligible. It follows that the yield is far from being a reliable measure of the effect of any treatment applied to soil with the object of controlling nematode.

While the degree of infestation of the test crop provides a useful measure, within limits, of the density of nematode in the soil, it fails to furnish any indication of the degree of injury inflicted on the plants.

The occurrence of root knot on tobacco may have any or several of the following effects:—

- (1) The plant may fail to make growth and die when young.
- (2) The plant may make a little growth and then become completely stunted, failing to produce any marketable leaf.
- (3) The plant may make a fair amount of growth, but the colour is yellowish and the leaves tend to be narrow and lacking in substance.
- (4) The leaves may wilt badly, even when the weather is not unduly hot, indicating an impaired sap-flow, with consequent deleterious effects on leaf development and ripening.
- (5) The leaves may wither, especially at the tips, presumably due to impaired sap-flow.
- (6) There may be no apparent effect on the plant.

Effect (1), as described above, appears to be rare in the case of clean tobacco seedlings planted in infested soil, except, perhaps, in soils of very low fertility. There has been no indication of a correlation between infestation and the final stand in the course of the experiments, although plants have been observed to die from severe root knot in very poor soil.

Of the remaining effects, the one which is most readily diagnosed is (2), and in view of the fact that such plants represent a complete loss to the grower, it is of interest that, with an equal degree of infestation, this effect is considerably more frequent in the case of soils of low fertility than in the case of soils in good heart.

The following records bear on the last statement:—

1.—In the series of experiments concerned with the effect of one season treatments on heavily infested soil, there were sixteen plots on which the test tobacco followed one season under kaffir beans, which are highly susceptible. The figures given in Table VI shows that all these plots were very heavily infested. On eight of the plots the great majority of the plants made very good to heavy growth, the leaves being dark green and ripening slowly. The tobacco in the surrounding area was of a similar type, indicating a fertile belt of soil. The remaining eight of the plots lay in a markedly less fertile belt, where the tobacco generally made less vigorous growth, the leaf colour was paler and the leaves ripened quickly.

Some chemical analyses, kindly carried out by the Chief Chemist, Department of Agriculture, indicated that, although the percentage differences were somewhat small, the soil in the first of the above categories

was somewhat the higher in clay content, and, on the whole, showed a better content of organic matter and nitrogen.

On 4th February a count was made of the completely stunted and wilting plants on each of these sixteen plots.

TABLE XVI

Showing the proportion of tobacco plants completely stunted by nematode attack on (1) Highly Fertile*, and (2) Less Fertile Soils, the infestation being approximately equal

Soil	No. of Plots	Mean % of Stunted Plants	Mean Infest. % 4, 2, 1, 0 vals.	Mean Yield lbs. p.a.
H.F.	7†	2.9 (SE 0.98)	90.6 (SE 1.70)	963
L.F.	8	18.2 (SE 3.29)	93.3 (SE 1.17)	625

The difference in the proportion of stunted plants is significant by "t" at the 1% point. The difference in mean infestation is not significant.

2.—Exp. 1, with *compost* applications, was situated in a portion of X land where the soil fertility was relatively low, and the infestation, as shown in Table VIII, was not quite as high as in the case of the plots dealt with above. On twelve out of the sixteen plots in this trial the fertility had, however, been built up by successive applications of compost of 4, 8 and 16 tons in respect to four plots each over three seasons. The remaining four plots had received no compost during this period. The growth of the tobacco was markedly better on the composted plots.

Chemical analyses of samples from plots which had received 16 tons of compost compared with samples from those which had received none gave a somewhat higher figure for organic matter and nitrogen, and a pH value which was markedly nearer neutrality. The clay content was much the same in all these samples, and compared with that of the plots in the one-season treatment trial, classified above as "less fertile."

TABLE XVII

Showing the proportion of tobacco plants completely stunted by nematode attack on (1) Composted, and (2) Non-composted Soils, the infestations being approximately equal. Exp. 1

Treatment	No. of Plots	Mean % of Stunted Plants	Mean Infest. % 4, 2, 1, 0 vals.	Mean Yield lbs. p.a.
Composted	12	1.8 (SE 0.75)	83.4 (SE 2.31)	862
No Compost	4	8.1 (SE 2.03)	81.4 (SE 2.23)	625

The difference in the proportion of stunted plants is significant by "t" at the 1% point.

The difference in the mean infestation is not significant.

* Relatively speaking; sandveld soil.

† One plot omitted on account of low infestation and very poor stand; side of old termite mound.

3.—Exp. 2, with *compost* applications, was situated on soil (Z land) which was considerably more fertile than that appertaining to Exp. 1. Although each plot had received the stated quantity of compost for two successive seasons, there was little apparent difference between the growth of the tobacco on the composted and non-composted plots respectively, and the growth was generally heavy.

The difference in the percentage of stunted plants in the composted and non-composted respectively was in this case not significant, but there are certain interesting points to be noted.

In one *non-composted* plot the infestation was excessively heavy, namely, 99.0% at 4, 2, 1, 0 values, and the proportion of stunted plants was 24.7%. In the other non-composted plots the infestation was considerably lower and the proportion of stunted plants was no higher than in those which had received compost.

There were two *composted* plots in this trial recording an infestation of 99.0%, one of which had received 8 tons and the other 16 tons. The respective proportions of stunted plants in these were 6.3% and 2.7%, giving some indication of advantage from the compost treatment.

This record would have little value in itself, but is given because it appears to furnish an example of intermediate conditions. The relatively high natural fertility of the soil more or less effectually counteracted heavy infestation on most of the plots, as far as complete failure of plants is concerned, but failed to counteract *excessively* heavy infestation on one plot that had received no compost, and was not altogether successful on the two similarly infested plots that had received compost.

4.—This leads to the final example in respect to the stunting of plants, which is furnished by the four plots in the Special Cotton Trial (see Table VII) that had been under kaffir beans the previous season. In these plots the infestation was excessively heavy throughout, registering a mean of 99.0% (SE 0.35). The mean proportion of stunted plants was 26.3% (SE 2.09). These plots were situated in the "highly fertile" belt, and the growth of the plants that escaped stunting was as heavy and the colour as dark as elsewhere in the vicinity. Chemical analysis indicated that the organic matter in the soil was equal to that of the "highly fertile" plots in Table XVI, but that the clay content was slightly lower, and was, in fact, similar to that of the "less fertile" plots in the Table in reference. The respective mean differences were: Clay, 6.2% against 7.8%; fine clay, 5.5% against 6.9%. The heavy growth of the tobacco was, however, a sufficient indication of the fertility of the plots, and the record appears to show, quite definitely, that there is a limit to the degree of nematode infestation which even high fertility, speaking in terms of flue-cured tobacco soils, can effectually counteract.

The effect of high fertility in counteracting heavy nematode infestation is still more clearly shown by the following figures:—

The trial with one-season treatments in heavily infested soil (refer p. 46) includes four blocks, A, B, C and D, and the difference in mean yield covering all the plots between the lowest-yielding block, namely, A, and the highest-yielding block, namely, C, was highly significant, confirming the very obvious difference in fertility noted during the growth of the crop. On block A, tobacco on the very heavily infested plots which had been under *kaffir beans* the previous season, showed marked nematode injury, as described above, while little such injury was observable on block C.

In the following Table, blocks B and D, which gave mean yields intermediate between those of A and C, are included, with due reservation, although the means are not in every case significantly different from those of the other blocks.

TABLE XVIII

Showing the disproportionate increase in yield of tobacco on (1) very heavily infested soil (foll. Kaffir Beans) compared with that on (2) less heavily infested soil (foll. plus/minus resistant treatments), relative to increase in soil fertility

Block	(1)		(2)		(3)		(4)		(5)		(6)	
	TMY	lbs. p.a.	MY f KB	lbs. p.a.	(2) as %	of (1)	Infes. f KB	as % of TM	MY f KB as % of MY f SH & VB	Infest. f KB as % of Mean f SH & VB		
A ..	..	814	544		66.6		139.1		57.4		151.4	
B ..	..	884	721		79.8		160.9		71.6		165.1	
D ..	..	936	854		90.2		161.2		83.6		167.0	
C ..	..	982	1,002		101.9		164.4		92.7		189.7	

TMY—Total Mean Yield, i.e., mean yield from all treatments;
 TM—Total Mean; MY—Mean Yield; f. KB—following Kaffir
 Beans; f. SH & VB—following Sunnhemp and Velvet
 Beans

A difference in the mean yields is significant by "F."

In the case of the *total mean yields*, a difference of 56-lbs. is significant at the 5% point. Therefore, C is higher than A and B, B and D are higher than A, and D is almost significantly higher than B, the other differences being non-significant.

In the case of the mean yields following *kaffir beans*, a difference of 215-lbs. is necessary for significance. Therefore, C is higher than A and B, and D is higher than A, all at the 5% point.

In the above Table, column (1) supplies a measure of the difference in fertility between the blocks as a whole; column (2) shows the effect of very heavy infestation following kaffir beans in reducing yield on the less fertile plots and the disproportionate increase with increase of fertility, compared with that following all the treatments, in which the average infestation was considerably lower. This is brought out in column (3) where the mean yield from the kaffir bean plots is expressed in percentage of that of the whole. Column (4) shows that the greater increase in yield is certainly not due to a lower relative infestation.

In columns (5) and (6), the mean yields from kaffir bean plots in the respective blocks are compared with those from the two other treatments in which a legume was turned under, namely *sunnhemp* and *velvet beans*. The differences between blocks in the mean yields following these treatments were non-significant, the infestation, although considerable, being apparently too low to cause appreciable reduction of yield even in the least fertile block.

There is, thus, considerable evidence that, as least in a good growing season, even heavy infestation with root knot nematode only reduces the yield of tobacco to a serious extent in soils of poor fertility. It may be

added that the results of the trials in the two previous seasons, when the rainfall was excessive, did not indicate that even a poor growing season made much difference in this respect. The above statements do not, however, apply to *excessively* heavily infested soils, such as are liable to be produced by growing susceptible crops for several seasons in succession.

It is also evident that it requires something more than one leguminous crop, turned in, to raise soil of low inherent fertility to a sufficiently fertile level to counteract heavy infestation, or, perhaps something more than organic matter is required. An example of this nature on a commercial scale came to notice on a farm in the district during the past season. The soil in reference was of a thin sandy nature, markedly white, and had had a crop of sunnhemp turned in early in the previous season. Infestation with nematode was heavy and the crop suffered severely, a considerable percentage of the plants being completely stunted and worthless.

A point which calls for further study is the response to heavy applications of *fertilizer* on heavily infested soil. The one trial of this nature carried out during the past season (see Table XV) gave no information in this connection, as the tobacco failed to suffer appreciably even at the lowest application.

It is possible that the chief mechanism in the counteraction of nematode infestation by high soil fertility is stimulation of production of fibrous roots. Such production was markedly more profuse on the more fertile plots, and the contrast was also noted in the case of the plots which had received the heavier applications of compost, compared with those which had received none, in Compost Exp. 1.

The above statements have no bearing on the all-important question of the *quality* of the leaf produced. This calls for a great deal of further study. It is very possible that soil fertility sufficiently high to produce a good yield in spite of heavy nematode infestation may also be too high for the production of good quality flue-cured leaf. While, therefore, keeping the soil in reasonably good heart is probably an important matter in growing tobacco on infested land, results obtained to date afford no indication that this can take the place of practice designed to control the nematode itself.

GENERAL SUMMARY AND DISCUSSION OF FIELD TRIALS

The primary object of these trials was to obtain data concerning the effect of different treatments on the density of nematode in the soil. It has been highly desirable, of course, to ascertain to what extent severity of infestation affects yield, but attempts to extract useful information concerning the effect of the different treatments on leaf quality have been incidental.

Three years of field trials with a crop like tobacco is, obviously, far too short a period to furnish conclusive results and to justify detailed recommendations concerning the most effective methods of controlling nematode. The only claim that can be made is that a foundation has been laid for further experimentation. A considerable amount of useful information has, in fact, been accumulated.

With regard to *nematode control*, figures have been obtained bearing on the relative values of bare fallow, weed fallow and a number of more or less resistant crops, singly or combined in rotations. Amongst resistant crops, *groundnuts* and *cotton* (9L34) have given markedly the best results in reducing nematode on very heavily infested soil. There has not been an appreciable difference between the effects of *sunnhemp*, *velvet beans* and *munga*, all of which are regarded as highly resistant. They failed, however, to reduce nematode from high density as much as the two crops mentioned above. On the other hand, *sunnhemp* produced very satisfactory results in the 1943-44 season on less heavily infested soil. On the latter, also, *maize*, following sunnhemp, did not increase the nematode population to a significant extent, and on the more heavily infested soil had some apparent nematode-reducing effect, which was not far short of that of sunnhemp. It should be emphasized that the order of value of these crops in respect to nematode control would not necessarily be the same in different seasons or, possibly, on different types of soil.

On the negative side, reasonably conclusive evidence has been obtained to the effect that *compost*, at least of the nature used in the trials and up to a maximum of 16 tons per acre, has no appreciable effect on the nematode itself, which has increased greatly in soils receiving different levels of compost for three seasons in succession.

Another negative result of interest is the failure of the local strain of *dhal* to control nematode. Varieties with a reputation in respect to nematode reduction are, however, to be obtained overseas, and might be imported for testing. Dhal affords such valuable browsing for cattle in the late dry season in frost-free areas that the importation for the purpose indicated would certainly be worth while.

With respect to *yield*, there has been little in the way of general correlation with degree of nematode infestation, whatever the nature of the season. The indications are that serious reduction in yield due to nematode attack is more or less confined to soils which are decidedly low in fertility or are excessively heavily infested. There seems to be something like a sliding scale in this respect between the severity of infestation and the productivity of the soil, but resistance to attack may, possibly, be due to some particular, but unknown, soil factor. In general, yields on infested soil have appeared to respond normally to fertility-increasing treatments, such as legumes turned under, or to the known soil-improving effect of cotton; but the effect of bare fallow on yield is an, at present, inexplicable exception and, as has been stated, may refer only to the type of soil on which the experiments were located.

It is clear that heavy-yielding crops of tobacco can be raised on heavily infested soil. Some of the very heavily infested plots on which tobacco followed kaffir beans, gave yields of well over 1,000-lbs. per acre. This statement applies to a season of low and intermittent rainfall, such as is generally regarded as conducive to maximum nematode effect on the crop. It may be of interest in this connection that the average yield from all the Thurbar experimental plots, covering slightly over seven acres, was 884-lbs. per acre. This, of course, included all the treatments, good, bad and indifferent, and many very heavily infested plots.

The *quality* of the tobacco produced during the past season on the infested soil was definitely on the poor side, the mean basic price being 6.7 pence per pound. An average good crop at basic prices would average around 9d. per lb., and this price was not reached in the case of any

treatment, or even any single plot. The average price obtained on the auction floor was 16d. per lb., giving a value of £58 19s. per acre. These averages are well below those referring to tobacco produced on the nematode-free soil on the Research Station itself.

In view of the facts that the low quality extended over (1) all treatments, (2) first-year as well as third-year land, (3) all degrees of natural fertility of the land, (4) all degrees of nematode infestation, and (5) a range of fertilizer applications from 200 to 600-lbs., it has become evident that there is some factor in the soil of the piece of land concerned that is inimical to the production of good quality flue-cured leaf, at least in a good growing season.

The *comparison* between treatments in respect to quality, of course, still remains, but there is something more than a possibility of some interaction between the inimical factor mentioned and the treatments, particularly in the case of bare fallow. Some of the results are, however, in harmony with those obtained in the United States of America, notably the relatively good quality following *cotton* and the poorer quality following *groundnuts*. *Maize* also gave indications in these trials of affecting the quality favourably, which is also the American experience.

Study of the effect of different rotation crops on yield and quality is, of course, primarily an agronomical undertaking and could be prosecuted to a large extent on nematode-free soil. It is, however, necessary that a great deal of further experimentation be carried out on infested soils, not only to collect more data concerning the effect of various treatments on the nematode, but to study the interactions between soils, treatment and nematode infestation in relation to injury to both yield and quality of leaf. For this purpose, a soil capable of producing high quality leaf is essential, and such a soil will certainly be lower in natural fertility than the greater part of the land used in the present trials. Experience to date indicates that it is only on such soils that reasonable correlation between degree of nematode infestation and yield, or, in other words, degree of injury to the crop, can be anticipated.

NATIVE AND WEED HOSTS

A few additions have been made to the host lists published in previous Reports and will be found in Appendix I of the present Report.

Identifications of some further host plants have been received, together with some further corrections of names already supplied. These are also given in the Appendix. Names of certain common weeds and veld plants are, however, still lacking.

INFESTATION OF SEED-BEDS WITHIN FLOOD-LIMITS OF STREAMS

With a view to adding to existing data concerning the danger of the nematode being present in the natural veld within the flood level of streams, an experiment was carried out as follows:—

In early September, a strip of ground was selected along the bank of a stream, the latter having long been suspected of harbouring nematode. This ground is very rocky and can certainly never have been in cultivation. Moreover, no water drains down to it from any nearby cultivated land. It lies, however, within the flood limits of the stream. The vegetation consists entirely of natural veld grasses and other plants which occur generally in damp situations on the sand veld.

Along about 200 yards of this strip of ground, twelve sites were selected at random and from each of these sites one pot was filled with soil. At the laboratories sunflower seeds were planted in all the pots, and the roots of the plants were examined after a period of growth of two months. Four out of the twelve pots gave positive results, the roots of the test plants showing numerous galls in each case, while microscopic examination revealed the presence of the root knot nematode in numbers.

As a control, 12 plots were filled from 12 sites selected at random *above* the flood level along the same stretch of the river, and sunflower seeds were planted as above. No sign of infestation was found in any of the test plants.

DEPTH DISTRIBUTION OF NEMATODE IN THE SOIL IN THE DRY SEASON

In last year's report, figures were given showing the depth, measured from the surface, of the nematode-free layer of soil month by month during the dry season and the rise of the nematode in the soil following the advent of the rains.

These records have been supplemented during the past year and an attempt has been made to ascertain the comparative density of infestation of different layers of soil, down to a depth of twelve inches, during different months.

For this purpose, a heavily infested plot was selected. This had been dug over, following harvest, in April and retained a loose surface. In July, August, September and October respectively soil was removed in two-inch layers from the surface to a depth of twelve inches, each layer being placed in a separate pot. Sunflowers were sown in the soil in each pot and the roots were examined after a suitable period of growth and before there was time for a second generation of the nematode to mature, i.e. around fifty days after the plants had germinated. A careful comparison was then made in respect to the degree of infestation of the roots from the different pots.

The results were as follows:—

TABLE XIX

Comparative infestation of two-inch layers of soil, measured from surface, in different months of dry season

2-inch Layers from Surface	Dates of Collecting Soil:			
	15th July	16th August	21st September	17th October
	Infestation	Infestation	Infestation	Infestation
1st (0-in.—2-in.) ..	Nil	Nil	Nil	*Negligible
2nd (2-in.—4-in.) ..	Light	Light	Moderate	*Negligible
3rd (4-in.—6-in.) ..	Light	Moderate	Heavy	Heavy
4th (6-in.—8-in.) ..	Light	Heavy	Heavy	Heavy
5th (8-in.—10-in.) ..	Light	Heavy	Heavy	Heavy
6th (10-in.—12-in.) ..	Light	Light	Very heavy	Heavy

* In the 1st 2-inch layer, one test plant out of four showed one small gall on one root tip only; it contained a female nematode and an eggmass.

In the second 2-inch layer, four small galls were found on six test plants; one contained a nematode female and the rest nothing.

The following Table gives the soil moisture determinations relative to the above:—

TABLE XX
Showing the water content of soil in two-inch layers from surface
(refer Table XIX)

2-inch Layers from Surface	Percentage Weight of Water to Weight of Dry Soil			
	Dates of Samples:			
	15th July	16th August	21st September	17th October
1st (0-in.—2-in.) ..	0.25	0.24	0.36	0.20
2nd (2-in.—4-in.) ..	0.99	0.47	0.95	0.39
3rd (4-in.—6-in.) ..	2.26	2.51	2.40	0.71
4th (6-in.—8-in.) ..	3.22	3.24	3.62	1.54
5th (8-in.—10-in.) ..	2.97	3.19	4.18	2.19
6th (10-in.—12-in.) ..	3.01	3.02	5.02	2.51
Means ..	2.12	2.11	2.76	1.26

It will be noted in Table XIX that by 17th October the top four inches of soil were practically free from nematode, a result which is in general conformity with records made last year. On 18th October, 0.44 inches of rain fell followed by 2.35 inches distributed between 7th November and 20th November. With the object of obtaining further data bearing on the return of nematode to the surface of the soil after commencement of the rains, six one-inch layers of soil were removed separately from the same plot on 22nd November. The three upper one-inch layers proved to be still practically free from nematode on this date. Wet season conditions persisted, and on 28th December a similar set of samples was taken. In this case all the layers were shown to contain nematode in considerable numbers. From this, and previous tests, it appears that the rise of the nematode in the soil with the rains is a relatively slow process.

Discussion

The results of these tests are consistent in showing the presence of a larger population of nematodes in the lower six inches of a twelve-inch section of soil compared with the upper six inches, at least during the period from mid-July to mid-October. It therefore appears improbable that additional working of the upper six inches of soil during the dry season will have any considerable effect on the infestation of the soil as a whole. This is in harmony with the results of the field trials in this connection (see Tables I and III).

These tests also confirm roughly previous records of the depth of the nematode-free layer at different periods during the dry season.

The phenomenon that the samples of soil taken on 21st September showed a higher water content than those taken in July and August has been paralleled in the case of previous determinations of this nature (see last year's Report). It is evident that some patches of soil retain moisture better than others, even within a few feet. It may be remarked that this relatively moist piece of soil also proved to be relatively heavily infested with nematode, but whether this has any significance or otherwise is uncertain.

SEEDBEDS WITH SOLID FLOORS

It is obvious that, if the soil used for raising seedlings can be cut off from communication with the soil beneath, a better control can be maintained over injurious soil-inhabiting organisms. It would be possible, for instance, to chance the soil altogether if necessary, while sterilizing treatments could be applied more economically and with more complete effect. As far as nematode is concerned it also appeared probable that the soil in such a seedbed would dry out sufficiently completely to eliminate the pest.

A seedbed embodying this principle was constructed at the Station in 1943. The floor consists of a single layer of bricks, thoroughly grouted with lime mortar, while the walls consist of two courses of bricks laid on the top of the floor layer and joined with lime mortar. The inside is plastered with lime mortar, but this is probably unnecessary. There are drainage holes at three-foot intervals in the lower course of the wall bricks. The internal dimensions of the seedbed are 50-feet by 4-feet by 7-inches high. The bed is divided into three equal portions.

The bed was filled with suitable soil level with the top of the walls, and was used in 1943 to raise infested seedlings for experimental purposes, the soil being heavily inoculated with infested root material. The seedlings grew satisfactorily under these conditions, and many were duly set out in the field. Examination of the roots of 100 seedlings taken at random indicated 100% infestation.

The unused tobacco plants and many weeds were left undisturbed in the bed until 1st March, when the bed was cleaned up. Some further growth of weeds occurred, chiefly Mexican Marigold and a final cleaning was given on 4th April, after which date no weed growth occurred. On 4th October watering was commenced, and on 9th October sunflowers were sown throughout the three sections of the bed to test for the presence of nematode.

The result of the test was a complete negative, the nematode having died out altogether in the six months under the conditions to which it was exposed.

It would appear, therefore, that, if properly cleaned up at the right time, seedbeds of this construction are self-sterilizing in respect to nematode, under conditions, of course, of the prolonged dry season which occurs in this colony.

Such seedbeds are not really expensive to construct, and might be found to meet a difficulty in certain circumstances.

VARIOUS EXPERIMENTS AND OBSERVATIONS BEARING ON THE LIFE ECONOMY OF THE NEMATODE

(1) LENGTH OF LIFE CYCLE.

In seeking data bearing on the length of the life cycle the method employed has been to grow the host plant in heavily infested soil for a period, then to lift it and keep portions of the roots on gauze tables in beakers, with sufficient water to reach the underside of the gauze and keep the roots wet by capillary attraction (Godfrey's method). The water was poured into test tubes daily for examination, being replaced by fresh water. By this method, it appeared easy to ascertain whether the roots had been taken up before the eggs of the second generation

had commenced to hatch, as this would be indicated by a time lag before larvae appeared in the water, while the length of the life cycle could, apparently, be measured to the first appearance of such larvae, and further to the beginning of mass hatching.

Furthermore, by testing roots with a shorter and shorter period of growth, it was hoped to ascertain the minimum period for the production of the first eggs; in other words the minimum period between the entry of the larvae into the roots and the attainment of reproductive maturity by the females which developed from them.

In the absence of facilities for controlling the soil temperature, or even of keeping a continuous record of its range, the results could not be correlated with the temperature to which the nematode had been exposed during development, and these preliminary experiments were only intended to furnish rough data. Results from a number of these tests were found to be difficult of explanation until it was suspected that there was a factor other than temperature which influenced the rate of development of the eggs, and largely vitiated the measurement of the life cycle by the method employed. This factor was apparently the continuous abnormally wet condition of the eggs in the beaker.

It appeared, in fact, that the shorter, within limits, the period of growth before the roots were taken up and put into the beakers, the earlier the larvae began to hatch out; which might tentatively be translated into a general statement that, other things being equal, the wetter the eggs the shorter the period of development.

It would serve no useful purpose to append a table of figures because of the lack of soil temperature records and the considerable margin of error, but the general tendency was clearly apparent, and could be tested out if thought worth while by anyone provided with the necessary facilities for exact work.

The shortest life cycle recorded with sunflowers as host plants, was 28 days to the first appearance of larvae, and 31 days to the commencement of mass hatching. This referred to plants grown in a *glass house* (opaque roof) during the hot weather (October). The roots were lifted and kept wet from the 21st day after the germination of the host plant.

In the *open* during the wet season (January—February), when sunflower roots were lifted 35-37 days after germination, periods of 41-44 days to the first larvae and 44-48 days to commencement of mass hatching were recorded.

In the case of the sunflowers grown in the *glass house* in the hot weather (October—November), a few larvae were hatched from roots which were only 14 days old, while appreciable hatchings were obtained under the same conditions from roots of 15 days' growth, and still more from roots of 21 days' growth.

On a *verandah* in the wet season (February), no hatchings were obtained from sunflower roots of 16 and 21 days' growth, but abundant hatchings occurred in the case of roots of 30 days' growth and upwards.

It appears, therefore, that the period of development of the females from larval stage to egg deposition may vary, influenced by relatively small differences of temperature, from as little as 14 days to over 21 days, and no doubt considerably beyond the latter figure at lower

temperatures. Under field conditions in the wet season in this Colony it would appear to require something over 40 days for the complete life cycle in sunflower roots.

Some comparative tests with *sunflowers*, *kaffir beans* and *tobacco* respectively revealed no significant difference between the periods of development in these three hosts.

(2) INFLUENCE OF WATER ON EGG DEVELOPMENT AND HATCHING.

The effect of thorough wetting in hastening the hatching of larvae from infested roots has been mentioned above. Certain other experiments have shown that the development and hatching of the eggs may be retarded and apparently arrested in default of contact with free water.

In these experiments infested roots were washed clean in running water and then dried with blotting paper until no free water could be seen. They were then placed on the gauze tables in the hatching beakers which contained a little water at the bottom to receive any larvae that hatched, but not enough to reach the gauze on which the infested roots lay. The beakers were then placed in desiccator jars with some water in the wells. The roots were thus exposed to a practically saturated atmosphere, so that they were protected from desiccation but had no contact with free water. Controls were kept from the same roots, these being kept wet in the usual way. Several tests of this nature were carried out.

The experimental roots produced a considerable number of larvae for a few days, presumably under the influence of the water absorbed during the washing process. They did not, however, produce nearly as many as the controls. After the first few days the number diminished rapidly until hatching practically ceased, the period being from two to something over three weeks.

In the meantime, the controls continued to produce larvae in abundance. After the practical cessation of hatching, the experimental roots were wetted and thereafter kept wet like the controls, with the result that in about two days they began again to produce larvae in considerable numbers. In one test, the experimental roots, after ceasing to produce even a single larvae for 10 days and having produced very few during the previous four weeks, were wetted 52 days from the commencement of the test. They then produced hundreds of larvae over the next eight days, when hatching abruptly ceased. During these eight days the controls, which were now approaching exhaustion, yielded less than half a dozen larvae daily. In other tests, when the experimental roots were wetted after a shorter interval, the renewed hatching continued over a much longer period, e.g. up to 40 days.

It is evident, therefore, that lack of contact with free water retards the hatching and, possibly, the development of the eggs and eventually arrests it altogether. The maximum period over which hatching can be arrested and the eggs still remain viable has not been ascertained.

Further evidence concerning the stimulating effect of thorough wetting on egg development and hatching is furnished by the large number of hatchings carried out in the course of the research work. Even in the case of old, growing roots, containing multitudes of females and eggs in all stages of development, which would undoubtedly have been producing larvae at a steady rate day by day when in the soil,

there has always been a time lag of from several days to about a week after the roots were put into the beakers before maximum mass hatchings occurred. These very heavy hatchings usually continued for a week or more before the yield of larvae began gradually to diminish.

(3) DURATION OF HATCHING FROM SEVERED ROOTS

The period over which infested roots, severed from the plant and subjected to the usual hatching technique, will continue to produce larvae is remarkable. In one outstanding instance, many thousands, diminishing to fully one hundred larvae daily, were obtained over a period of one hundred days and smaller numbers over a very much longer period.

It appears, therefore, that the rate of development of individual eggs is very variable, even under wet conditions.

(4) SURVIVAL IN SOIL WITHOUT HOST PLANTS.

The experiment with the seedbeds constructed with solid floors, already described, indicates that the nematode cannot survive in thoroughly dry soil over a period of six months. Other experiments on survival were carried out in pots, and the soil was watered regularly.

(a) *Infested Roots.* In this experiment pieces of infested roots containing eggs and other stages were buried in the soil which was watered daily, and sunflowers were planted at intervals of thirty days to test for nematode survival. Considerable survival was registered after 90 days, a small survival after 120 days, but none after 150 days.

(b) *Larvae Only.* In these experiments sterilized soil was used. A water-suspension of many thousands of newly hatched larvae was kept well stirred while being divided into six equal parts, and each part was then poured into holes in the soil of each of six pots. Survival was tested by planting sunflowers, as in the previous experiment, but owing to the pressure of other work, the thirty-day interval between sowings was not quite strictly adhered to. Two series were included in the test, the one being started a few days after the other. The first pots were planted with sunflowers immediately after the larvae had been introduced into the soil as a control to the later plantings. In the control pots the sunflowers became freely galled, but no survival occurred after 32 and 36 days respectively in the pots planted later.

Godfrey has shown that persistence of nematode is more prolonged, in the absence of host plants, in dry soil than in soil that is regularly watered, due to the fact that the larvae remain quiescent in the former but exhaust their vitality by activity in the latter. He has shown further, however, that in the soil that is neither wet nor dry, i.e. containing only its *moisture equivalent* of water, larvae can survive for over 40 weeks. This appears sufficient to explain the survival of nematode in bare soils in Southern Rhodesia over the dry season. There appears to be no adequate explanation of the survival of nematode in completely bare soil over the wet season, although it certainly does survive these conditions with considerable success.

(5) BREEDING IN THE DRY SEASON

Examination and testing of tobacco plants left standing in infested soil in the field during the dry season have revealed that breeding continues freely, at least as late as September. No plants survived

until October. Root material from these plants when put to hatch larvae in the usual way yielded large numbers as soon and over as prolonged a period as infested roots from regularly watered soil. The wisdom of cleaning up infested land as quickly as possible after harvest and of keeping it free from living weeds during the dry season is obvious.

WATER PRESSURE AND NEMATODE LARVAE

An enquiry was received from a tobacco grower as to whether a pressure of 100-lbs. was sufficient to kill any nematode larvae immersed in water. The enquiry referred to conditions in a pipe leaving a pump that was lifting the water for seedbeds sufficiently high to produce the pressure mentioned. In order to test this, a pressure apparatus was made to order, which admitted of the insertion of a test tube containing living larvae in water. Unfortunately, the apparatus failed to hold a high pressure for any considerable length of time. Several experiments were, however, carried out, the pressure being raised to over 100-lbs. (125-lbs. and 130-lbs. in different tests) and remaining over the 100-lb. mark for five minutes or more.

There was no discernable effect on the larvae, either immediately or after an interval of 24 hours.

SUGGESTIONS TO TOBACCO GROWERS

It is obvious that, however much information may eventually be made available from research work concerning methods of dealing with infested lands, much experimentation will need to be carried out by the tobacco growers themselves to adapt it to their particular conditions. Many growers are, in fact, already experimenting with rotations. A few suggestions at the present stage of the investigation may, therefore, not be out of place.

Clean seedlings are, of course, the first necessity and recommendations in this connection have been made in last year's Report and elsewhere. It may, however, be emphasized that virgin land is liable to be infested if any water drains down to it from cultivated, or previously cultivated, land at a higher level. In selecting the site for seedbeds, this fact should be borne in mind in addition to the strong recommendation already made concerning the avoidance of sites within the flood limits of streams.

Where it is necessary to reduce heavy infestation in land before planting tobacco, the indications are that more than one season's treatment will be necessary. In the United States of America, two seasons' treatment is generally recommended.

The *bare fallow* treatment, which is probably the most drastic of all, is, in the first place, not a very practicable operation and, in the second place, is not generally regarded as good for either yield or quality of tobacco following it. The quality and yield obtained with this treatment on the Thurbar land may be misleading with reference to better tobacco soils.

Groundnuts and *cotton* (9L34) seem to be almost, if not quite, as effective as bare fallow in reducing nematode, and the inclusion of one or other of these crops in the rotation on heavily infested land is indicated. Cotton appears to have the better effect on quality and yield

and should therefore be the more suitable immediately to precede tobacco. A short rotation which suggests itself would be:—*sunnhemp* (turned in ? late)—*cotton*—*tobacco*. Growers will no doubt have their own ideas about practicable rotations and, applying the rules of good farming practice, should be able to evolve something suitable for their own farms and circumstances. It appears, however, that if the land is really heavy infested, either *cotton* (9L34) or *groundnuts* (Bunch), or both, should be included, while on most lands the principle of interposing a cereal between a legume and tobacco should be adhered to.

If it is merely a question of keeping a moderate infestation under control, a rotation consisting of *sunnhemp* (turned under late)—*maize* or *munga*—*tobacco* may prove suitable.

The effect of *grass leys*, which are regarded by many growers as the only really satisfactory practice with the object of restoring the soil to virgin condition, has not yet been tested experimentally. From observation it is, however, doubtful if, even were the grass sufficiently resistant, it could be made to take adequate possession of the soil to suppress nematode. Many nematode hosts tend to intrude quickly into any grass land on the sandveld, and by the second year a grass ley does not appear likely to be much more effective than weed fallow. *Weed fallow*, at least as it occurs in and around the Trelawney area, is certainly not a nematode-suppressing treatment.

Growers might consider the question of farming all lands as if they were nematode-infested. While this would necessitate leaving out certain useful crops, such as kaffir beans, upright cowpeas, etc., it would minimise the risk of the grower sustaining a rude shock one day. Incipient infestation of the soil with nematode is not always promptly detected. Uprooted tobacco should, in any case, always be examined for the possible presence of this insidious pest.

Commonsense dictates that infested land should be ploughed as soon as possible after harvest and kept free from weeds during the dry season. This appears to be an easy undertaking. Nematode certainly survives the dry season in considerable proportion in bare soil, but it continues to breed in living hosts throughout this period.

Hilling, as advocated by A. D. Collins (see R. A. Journal, June X 1938 and Annual Reports for 1943 and 1944), appears to have some advantage over *ridging* on infested soils.

Finally, it seems to be important to keep the soil in as good heart as is consistent with the production of good quality leaf. Nematode infestation causes the greatest injury to the crop on poor soils.

ACKNOWLEDGMENTS

The writer has pleasure in acknowledging further assistance in botanical matters from Miss Kathleen Sturgeon, Division of Plant Pathology, Salisbury during the past year.

Furthur, at the conclusion of his three years of research work at the Research Station, he desires particularly to express his thanks to his fellow workers for their never-failing ready assistance and advice.

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APPENDIX I

NATIVE AND WEED HOSTS OF HETERODERA MARIONI.

A few further additions have been made to the list of host plants given in previous reports.

The basis of classification were described in the 1943 Report. Briefly, Classes 1, 2 and 3 indicate three diminishing degrees of susceptibility, while Class 4 indicates that no infestation has as yet been obtained in pot tests or observed in the field. "N.C." indicates "not classifiable" on the basis of available data. "P" indicates "pot culture test" and "F" field observations."

Family and Species of Plant	Class of Host	Basis	Chief Habitat of Host and Remarks
<i>Gramineae</i>			
<i>Cynodon dactylon</i> , Pers	 3	P	Common grass.
<i>Chenopodiaceae</i>			
<i>Chenopodium ambrosioides</i> L. ...	3	P	Occasional weed.
<i>Amarantaceae</i>			
<i>Alternanthera repens</i> (L), O. Kuntze	 2	P	"Khaki Weed."
<i>Rosaceae</i>			
<i>Alchemilla</i> ? <i>inyangensis</i> , Weimarck	 4	P	River banks and marshy ground.
<i>Leguminosae</i>			
<i>Cassia occidentalis</i> , L. (No. 258)	4	P	N.B.—The Cassia given this name in last year's Report is a different species.
<i>Indigofera rhynchocarpa</i> , Welw.	2	P	Scattered through forest.
<i>Indigofera demissa</i> , Taub. (No. 153)	 3	P	Ex N.C. in 1943 Report.
<i>Glycine albidiflora</i> , de Wild.	 3	P	Natural forest and waste ground.
<i>Rhynchosia resinosa</i> , Bak.	 2	P	Natural forest and waste ground.
<i>Brachystegia randii</i> , Bak. f.	 4	P	"Msasa." Dominant forest tree.
<i>Brachystegia woodiana</i> , Harms.	4	P	"Mfuti." Dominant forest tree.
<i>Euphorbiaceae</i>			
<i>Phyllanthus</i> ? <i>maderaspatensis</i> , L.	 4	P	Weed of cultivated and fallow ground.
<i>Malvaceae</i>			
<i>Sida carpinifolia</i> , L.	 2	P	Waste ground.
<i>Labiatae</i>			
<i>Leucas</i> ? <i>randii</i> , S. Moore	 3	P	Natural forest.
<i>Orthosiphon rubicundus</i> , (D. Don), Benth.	 1	P	Natural forest and waste ground.
<i>Rubiaceae</i>			
<i>Anthospermum randii</i> , S. Moore	2	P	Roadsides and waste ground.

Attention may be directed to the fact that no infestation was obtained in pot tests with either the "msasa" (*Brachystegia randii*) or the "mfuti" (*Brachystegia woodiana*), two of the dominant forest trees in Mashonaland. The third dominant, the "mnondo" (*Isoberlinia globiflora*), was found to be a host of the nematode, as indicated in the 1943 Report.

CORRECTIONS OF BOTANICAL NAMES GIVEN IN PREVIOUS REPORTS

There are a few further corrections to be made in the names of native plants and weeds tested for susceptibility to nematode attack, as given in the two previous Annual Reports. The numbers in brackets refer to the writer's collections which have been lodged with the Division of Plant Pathology at Salisbury.

1. *Bidens* sp. (No. 160).—In last year's Report the determination of this plant is given as *B. ? bipinnatus*, L., but this has now been corrected to *B. quadriseta*, Hochst. There is a suspicion that *quadriseta* is only a form of *pilosa*, the common "Blackjack," but if so, it appears to be a very distinct variety. Apart from morphological differences, it is much slower maturing and only seeds once a year, in March. Moreover, it is highly susceptible to nematode attack, while *pilosa* is apparently very resistant.

In the latter connection, it may be stated that the report against *pilosa* in the 1943 Report must be accepted with reservation. A considerable number of subsequent tests failed to produce any infestation in this species, and it is suspected that the seeds of *pilosa* and *quadriseta* may have been mixed in the original trials.

2.

<i>Names in Previous Reports</i>	<i>Corrections</i>
<i>Cassia occidentalis</i> , L.	<i>Cassia goratensis</i> , Fres.
<i>Crotalaria buehneri</i> , Bak. f. ..	{ <i>Crotalaria bequaertii</i> , Bak. f.
<i>Crotalaria</i> sp. (No. 130)	
<i>Crotalaria</i> sp. (No. 143)	<i>Crotalaria ? buehneri</i> , Bak. f.
<i>Indigofera</i> sp. (No. 153)	<i>Indigofera demissa</i> , Taub.
<i>Oldenlandia thymifolia</i> , Prantl. ..	{ <i>Oldenlandia cynanchica</i> (DC),
<i>Oldenlandia</i> sp. (No. 184)	
<i>Tephrosia capensis</i> , Pers. Ench. ..	{ K. Schum.
<i>Tephrosia</i> sp. (No. 67)	
<i>Tephrosia ? flexuosa</i> , Don. (No. 110) }	{ <i>Tephrosia godmanae</i> , Bak. f.
<i>Tephrosia delagoensis</i> , Verdoorn in }	
lit.	{ <i>Tephrosia</i> sp. nov.
<i>Tephrosia noctiflora</i> , Boj.	{ <i>Tephrosia polystachya</i> , E. Mey.
<i>Tephrosia</i> sp. (No. 50/90)	
<i>Vigna lutea</i> , A. Gray.	{ <i>Vigna vexillata</i> , Benth, var.
<i>Vigna</i> sp. (No. 123)	
	{ hirta.

APPENDIX II

COMPOSITION OF WEED FALLOW IN DIFFERENT TRIALS

The notes refer to growth in the 1943-44 season, i.e., that preceding test tobacco grown in the past season.

1.—*Dhal. v. Weed Fallow. Exp. 1, X Land.*

Dominant.—*Rhynchelytrum roseum* (Natal Red-top Grass), *Erigeron canadensis* (Horseweed) and *Tagetes minuta* (Mexican Marigold).

Frequent.—*Indigofera hirsuta*, *I. demissa*, *Lotononis* sp., *Trichodesma zeylanicum*, *Eleusine indica* (Rapoko Grass).

Occasional.—*Tephrosia* sp. (No. 100), *Crotalaria anthyllopsi*, *Hibiscus cannabinus*, *Lightfootia denticulata*, *Orthosiphon bracteosus*, *Oldenlandia* sp., *Ceratotheca triloba*, *Lippia asperifolia*, *Blepharis caloneura*.

Forest Tree Root-suckers.—*Isoperlinia globiflora* (Mnondo), *Strychnos spinosa* (Kaffir Orange), *Parinarium mobola* (Mahasha), *Combretum* sp., *Gymnosporia* sp.

Survived Dry Season (1944).—Apart from root-suckers of forest trees: *Erigeron*, *Trichodesma*, a few *I. hirsuta* and a few grass plants.

2.—*Dhal v. Weed Fallow. Exp. 2, Z Land.*

Dominant.—Rapoko Grass and Mexican Marigold.

Frequent.—*Indigofera hirsuta*, *Indigofera demissa*, *Lotononis* sp., *Cassia mimosoides*, *Crotalaria anthyllopsi*, *Crotalaria microcarpa*, *Vigna vexillata*, *Hibiscus cannabinus*, *Ceratotheca triloba*, *Tephrosia* sp. (No. 110), *Cleome monophylla*, Natal Red-top grass.

Occasional.—*Indigofera* sp. (No. 114/128), *Crotalaria hyssopifolia*, *Sphenostylis erecta*, *Aeschynomene rhodesiaca*, *Rhynchosia* sp., *Amarantus thunbergii*, *Erigeron canadensis*, *Bidens pilosa*, *Waltheria americana*, *Polygala arenaria*, *Sida* sp., *Cucumis* sp., *Borreria dibrachiata*, *Eragrostis viscosa*, *Pogonarthria squarrosa*.

Forest Tree Root-suckers.—Mnondo, *Brachystegia woodiana* (Mfuti), *Combretum* sp., Mahasha.

Survived Dry Season (1944).—*Indigofera hirsuta*, *Tephrosia* sp., *Erigeron*, *Ceratotheca*, *Waltheria*, *O. bracteosus*.

3.—*One-season Treatments on Heavily Infested Soil.*

Dominant.—Rapoko Grass, Mexican Marigold, Natal Red-top Grass.

Frequent.—*Lotononis* sp., *Hibiscus cannabinus*, *Cyperus amabilis*, *Eragrostis viscosa*.

Occasional.—*Cassia mimosoides*, *Crotalaria anthyllopsi*, *C. hyssopifolia*, *Vigna vexillata*, *Sphenostylis erecta*, *Indigofera* sp., (No. 114/128), *Trichodesma zeylanicum*, *Gynura cernua*, *Bidens pilosa*, *Cleome monophylla*, *Phyllanthus humilis*, *Corchorus tridens*, *Biophytum apodiscias*, *Borreria ruelliae*, *Eragrostis ciliaris*, *Pogonarthria squarrosa*.

Forest Tree Root-suckers.—Mnondo, Mfuti, Kaffir Orange, *Combretum* sp., *Burkea africana*.

Survived Dry Season (1944).—Refer 2. above.

4.—*Special Cotton Trial.*—Practically the same as 2 above, the trials being adjacent. The susceptible hosts, *Indigofera hirsuta* and *Hibiscus cannabinus* were, however, more abundant on an average.

VII—Soil Insect Pests

The writer took up his duties on the Research Station in December, 1944, and commenced a study of soil insect pests with a view to their control.

The first essential was to find out what insects were present in the soil and which of them were damaging tobacco. Examination of the large field collections of insects showed less than 1% of all insects present to be other than white grubs (*Scarabacidae*). The majority of the remainder were false wireworms (*Tenebrionidae*), crickets (*Brachytrypes membranaceus*) and cutworms (*Noctuidae*) were very scarce. Other insects present belonged to families not likely to damage tobacco. It was, therefore, decided to concentrate work on white grubs. Later in the season, wireworms have received some attention, but insufficient information has yet been gathered about these pests or about crickets and cutworms to warrant further mention in this Report.

Since work was commenced in the middle of the season, the full annual life cycle has not yet been observed.

WHITE GRUBS

Approach to the problem has been made from the following angles:—

- (1) To ascertain how many species are present, and what characteristics can be used to differentiate between these species in the field.
- (2) To find out whether all species damage tobacco and, if not, which are the more important.
- (3) To find out what these species are by rearing them to the adult stage.
- (4) To measure the damage caused.
- (5) To measure the field populations of each species, and to observe the annual cycle of events including growth, mortality and emergence of adults.
- (6) To gather together such knowledge as has thus been gained and to plan experimental work for the coming season to study the effects on white grubs of various cultural practices in use among tobacco growers.

Field Observations

Eight species of grubs were present which were large enough to damage tobacco plants. Five of these species were present in sufficient numbers to be serious if they damaged tobacco plants. In order to find out which species were actually damaging tobacco, a series of brick boxes were constructed in which tobacco could be grown open to the weather. Each box was made a square yard in area, and the whole surrounded by a water gutter to exclude surface predators. Fifteen grubs together with six tobacco seedlings were placed in each box. Each species was tested in two boxes and the commoner larger species Nos. 1 to 5 were all represented. A further two boxes each contained forty

grubs of a mixture of the three common small species. Typical damage was caused by all the larger species except No. 4. One plant was damaged in one of the boxes containing the smaller species.

This damage occurred in spite of the fact that the test could not be carried out until February when damage had ceased in the field and many of the grubs were ceasing to feed, and were commencing diapause.

When tobacco seedlings are transplanted, they are placed deep into the soil in order that adventitious roots may be formed from the lower part of the stem and obtain quick contact with the fertilizer. It is this below-ground section of the stem which is damaged by white grubs. Damage is sometimes at, or near, the surface of the ground, but is more commonly between $1\frac{1}{2}$ and 3 inches down. Direct damage to roots has not been observed, and if it does occur it is unimportant. A transplant can be severed and killed by one grub.

The loss of plants was studied in two fields on the Station. *Field A* was third-year land on very heavy soil, planted on 26th December and refilled on 6th January.

TABLE I
Field A
Causes of plant loss as percentages of full stand

		White Grubs	Wire-worms	Crickets & Grass-hoppers	Non-Insect Causes	Total
1.—Before refilling	..	12.5%	nil	0.3%	16.4%	29.2%
2.—After refilling	..	22.1%	nil	1.1%	8.4%	31.6%
Total	.. ..	34.6%	nil	1.4%	24.8%	60.8%

Insect damage had virtually ceased by 25th January, four weeks after planting.

Field B was first-year land on a very light, sandy soil. It had been cleared in July, 1943, and ploughed in March, 1944. It was planted on 4th January and was not refilled.

TABLE II
Field B
Causes of plant loss as percentages of full stand

White Grubs	Wireworms	Crickets and Grasshoppers	Non-Insect Causes	Total
29.0%	2.4%	1.6%	4.8%	37.8%

Insect damage had virtually ceased by 25th January, only three weeks after planting.

It is probable that both of these Tables underestimate wireworm damage, as it is not yet possible to differentiate between these two causes unless the insect is found in the act. However, wireworms were scarce in both fields, and cannot have caused economic damage.

Above this total loss, nearly 50% of the remaining plants in both fields received non-fatal injury to a greater or lesser extent. In these cases, the stem had been damaged but had not been severed, and the

plant, although checked, had managed to survive. It is difficult to assess the economic loss due to this type of injury; but it is believed that, as long as the plant is able to establish a good bunch of adventitious roots, the damage is not great.

TABLE III

Mean numbers of white grubs per acre during January, 1945

			Field A	Field B
A.—Last instar larvae:	Species 1	.. ..	10,830	8,470
	Species 2	.. ..	1,640	2,180
	Species 3	.. ..	4,740	4,290
	Species 4	.. ..	7,870	9,550
	Species 5	.. ..	1,310	16,570
	Other rarer spp.	.. ..	360	—
B.—Small instars all spp.	.. ..	.. ..	8,560	11,190
	Total injurious white grubs	.. ..	35,310	52,250
	Total harmless white grubs	.. ..	16,770	11,490
	Grand Total	.. ..	52,080	63,740
No of plants killed per acre	.. ..	.. ..	1,675	1,430

Thus, although the loss of stand has been economically heavy when compared with the white grub populations present, the damage has not been as great as it might have been. In Field A only one grub in every 21.1 potentially injurious grubs, and in Field B only one grub in every 36.6 has actually taken a plant. Tobacco cannot, therefore, be a preferred food of these insects.

THE LIFE CYCLE, GENERAL

The oviposition period has not yet been observed, but lies sometime during the hot season or early rains. Grubs are active during the early part of the rainy season, grow fast, quickly reach their last instar and continue to feed for several weeks. When full fed, the grubs form cells in the ground, frequently within or against a clod, evacuate the gut and diapause as larvae.

During March and April, a smaller number of grubs pupated and emerged as beetles only to continue to diapause as adults. Pupation ceased during the cold weather and recommenced during the second week of August.

In order to be able to plan experimental work for white grub control during the coming season, it was necessary to know the length of the life cycle. In other parts of the world, other species of these beetles take upwards of three years to grow to maturity; but it was previously believed that Rhodesian species underwent their complete life cycle within twelve months. From the practical point of view, it is of the utmost importance to know whether it is necessary to have to deal with a carry-over of large grubs from the previous season, or whether the infestation is always a new one due to the egg-laying of beetles in the same year. A quick forecast was, therefore, essential. By the middle of May all individuals

of all species were in a state of diapause and all were in their final larval instar. It was reasoned that if two years were the normal length of life then the first year fraction of the diapausing larvae might recommence feeding at the beginning of the rains, while the second year fraction would emerge as beetles after the cool season. In these circumstances, the mean weights of the first year diapausing larvae would be less than the mean weights of the second year diapausing larvae. Therefore, during May 878 grubs belonging to the five important species were weighed. The weights for species Nos. 1, 3, 4 and 5 were all grouped round a single mean, and it was considered safe to forecast a duration of twelve months only to the life cycles of these species. With species 2, however, the sample was small and the curve irregular so that it was not possible to be definite. At the time of writing this Report, in late September, it is apparent that the forecast of a twelve month life cycle was correct. The number of grubs now remaining in the soil is very small, and by their condition it is possible to say that all are about to pupate. Pupation never lasts more than a very few weeks.

Among all species, the greatest mortality occurs between January and March and the chief causes are diseases believed to be bacterial. There was a very small incidence of parasitism by Scoliid wasps but these were, in their return, very heavily parasitized by Bombyliid flies of the genus *Anthrax*. During the latter part of the season, the flies were very much more plentiful than the wasps. Between April and July, the decline of population due to mortality was small.

THE LIFE CYCLES, SPECIFIC

Species 1. Anomala sp. This is the largest grub and was present in the greatest numbers during the critical period for the tobacco. It is believed to have been responsible for greater damage than any other species. During January and February it was attacked not only by the bacterial disease already mentioned, but it was also heavily parasitized by a fungus of the *Entomophthora* type and is the only species in which a fungus disease was observed. The incidence of this disease rose to over 30% on one occasion. It ceased feeding between 15th January and 9th March.

Species 2.—This, another large grub, was present in its last instar only in very small numbers at the time of planting the Virginia tobacco and can, therefore, have done no economic damage to that crop. It was the slowest species to develop, and attained the peak of its population during February in the order of 3,900 to 10,900 per acre. It was the only species still feeding when the Turkish tobacco was planted and it did considerable, unmeasurable, damage to this crop. It ceased feeding between 2nd March and 18th May.

Species 3.—This, the third common large species, was present at over 4,000 per acre at the time of planting the Virginia crop. It ceased feeding between 19th January and 12th March.

Species 4.—This is a smaller species, and was present at the rate of 7,000 to 9,000 per acre at the time of planting the Virginia crop. It ceased feeding between 22nd January and 23rd March. Although this species was not shown to cause damage in the box tests during February, this negative result is not considered conclusive.

Species 5, Anomala sp.—This is the smallest species believed to be capable of causing damage. It showed more variation than other species in the size of its populations between fields. Field A contained only 1,300 per acre against 16,000 per acre in Field B. It ceased feeding between 19th January and 20th April.

DISTRIBUTION IN NATURE

During April a search was made in the veld to see whether these grubs were present. This was not carried out on a scale sufficiently large to give a statistical sample, but it was evident that, although species 1, 3, 4 and 5 were all found, all species were very much more scarce in the veld than in cultivated fields. Various species appeared to show preferences for particular plant associations. A considerable number of other species, mostly small, were present.

LARVAL REARING

A series of grubs of each species has been reared in the laboratory for purposes of identification of the adults. Individual grubs are reared in 4-oz. or 8-oz. jam jars and fed solely on a mixture of top soil and compost. To prevent the soil from drying, yet to maintain it in a suitable condition, the jam jars are kept in a saturated atmosphere in larger glass containers. Owing to the lower temperatures prevailing in the laboratory to those in the surface soils of the fields, development has been slower than under natural conditions, and some of the species have not yet been identified. The following species have been shown to be present—two species of *Schizonycha*, one species of *Adoretus* and five species of *Anomala*.

